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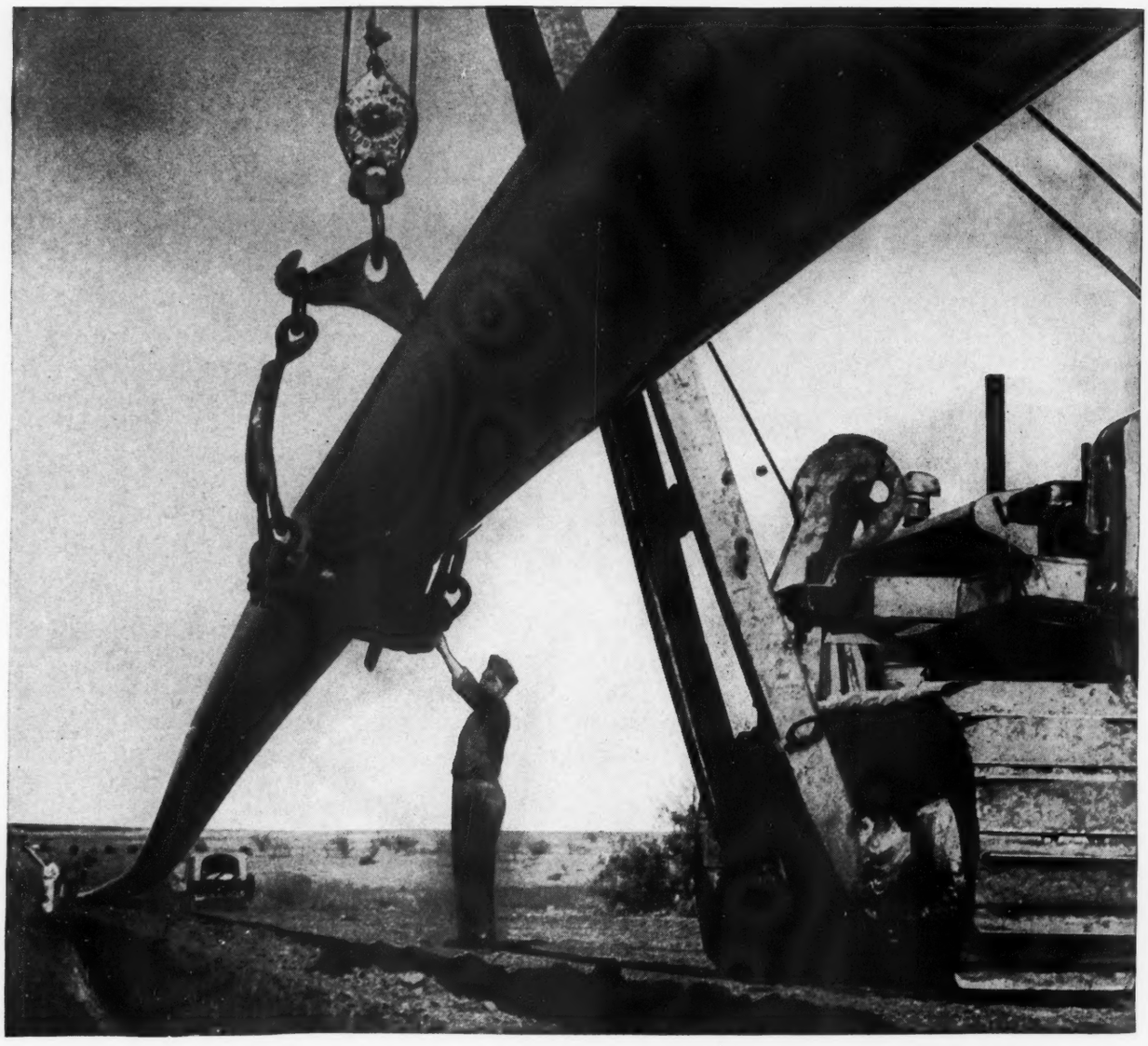
the tech engineering news

February 1950

How America's "Underground" works for you



THERE are enough miles of oil and natural gas pipe lines in the U. S. A. to circle the world at the equator 16 times!

This vast, 402,000-mile network is made up of crude oil lines, oil products pipe lines and natural gas lines. This network has helped to make the benefits of gasoline, fuel oil and oil products readily available to everybody . . . it has helped to bring gas heating to many parts of the country.

But this constantly-expanding underground network is far from complete. It will require thousands more miles of pipe in the near future. To help meet this demand, United States Steel will put two more large-diameter pipe mills into operation in the next few months.

The steel industry is a growing industry, not only in terms of physical plants and facilities, but in terms of personnel, too. At the present time, the number of United States Steel employees participating in educational programs is exceeded in size only by the student bodies of a few of our largest universities.

The fundamental objectives of these programs are to assure employees maximum opportunity for personal development and to provide them with a sound foundation for advancement within the organization.

The training programs in United States Steel have become the "pipe line" to successful careers for hundreds of capable young men.

AMERICAN BRIDGE COMPANY · AMERICAN STEEL & WIRE COMPANY · CARNEGIE-ILLINOIS STEEL CORPORATION · COLUMBIA STEEL COMPANY
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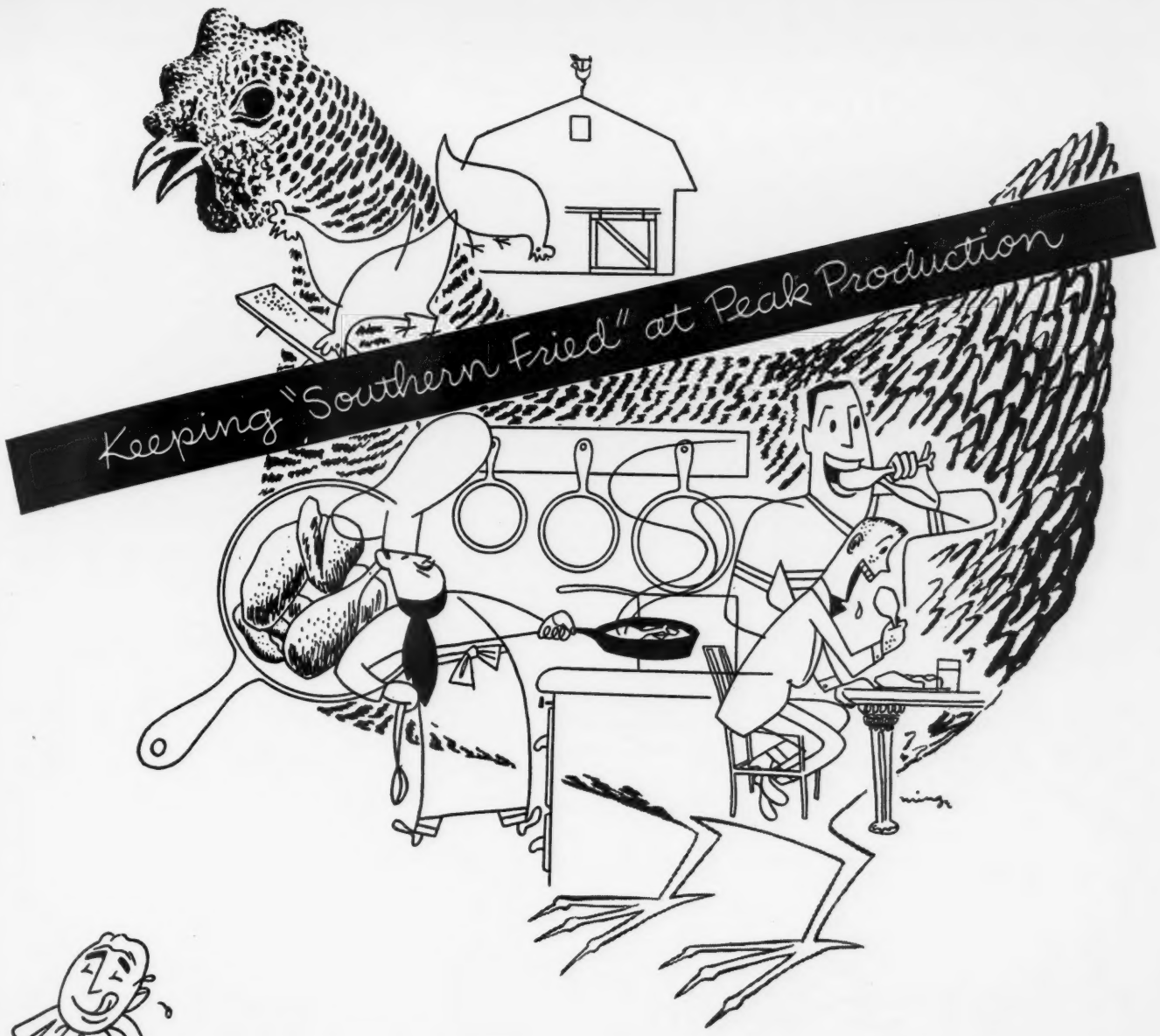
USS

UNITED STATES STEEL



Hmmmm-*mmm!* Southern fried chicken, golden-brown and crispy. Man, oh, man . . . what a treat!

Well, mister, you can thank Methionine, an essential amino acid, for helping to bring better quality and less expensive poultry to the family table.

Chemistry and southern fried ???????

That's right, for today, chemistry plays an indispensable role in nutrition. For several years biochemists have recognized the nutritional importance of amino acids, the building block of proteins. Several of these amino acids are essential to the diet, for without them man and animal cannot grow or maintain life. Methionine is one of these essential amino acids.

Dow's continuing research, along with that of other investigators, has proved that critical deficiencies of Methionine can be corrected by supplementing chicken feed with this amino acid, produced synthetically. Chickens fed fortified diets grew ten per cent faster and consumed less feed for every pound gained. Such new developments make it possible for poultry raisers to market better quality birds more frequently and more economically.

Experiments with amino acids and their importance in the nutrition of man and animal, are but a small part of the continuing research program in many fields which is carried on by Dow—in the interest of producing more "Chemicals Indispensable to Industry and Agriculture."

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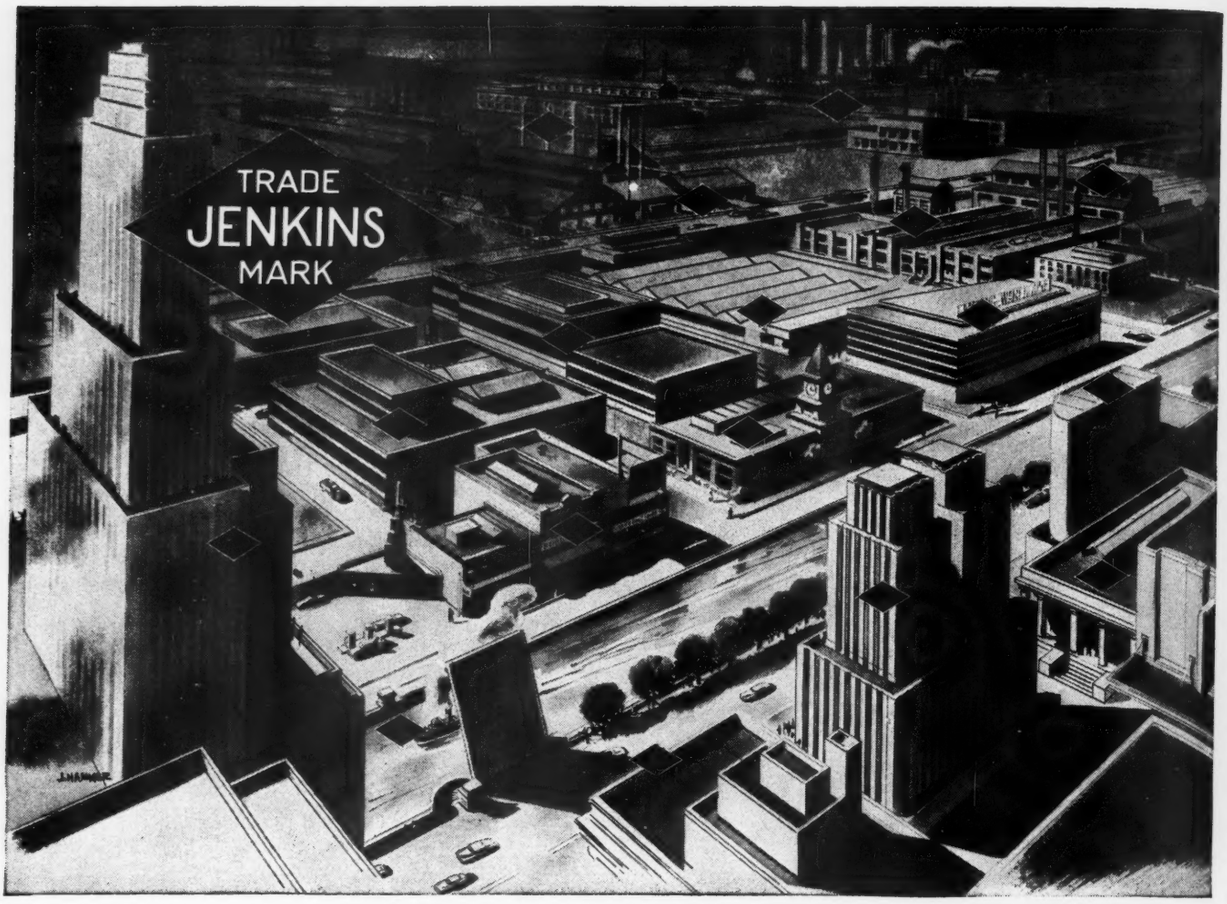

Acres of Diamonds

YOU SEE only the structures of commerce, soaring skyward . . . the strange new shapes of industry stretching beyond. Yet all around you are acres of diamonds. Diamonds that identify the thousands of Jenkins Valves on duty in the many different types of buildings essential to modern civilization.

Nothing holds its value like the diamond, in valves as in gems. Four generations of American builders have placed their trust in the Jenkins diamond and signature trade mark. Today, as in 1864, Jenkins Valves are the choice of men who plan shrewdly, always with an eye to future maintenance and operating costs.

They know that Jenkins builds extra *endurance* into Valves — proved by long life and low upkeep cost records in every type of service. They know, too, that there is extra value in the *experience* Jenkins Valve specialists can apply to any question of selection, installation, or maintenance.

They pay no more for Jenkins Valves, despite this superior quality and service. That's why the Jenkins diamond remains the guide to valve economy . . . for new installations, for all replacements. *Sold through leading Industrial Distributors everywhere.*

JENKINS VALVES

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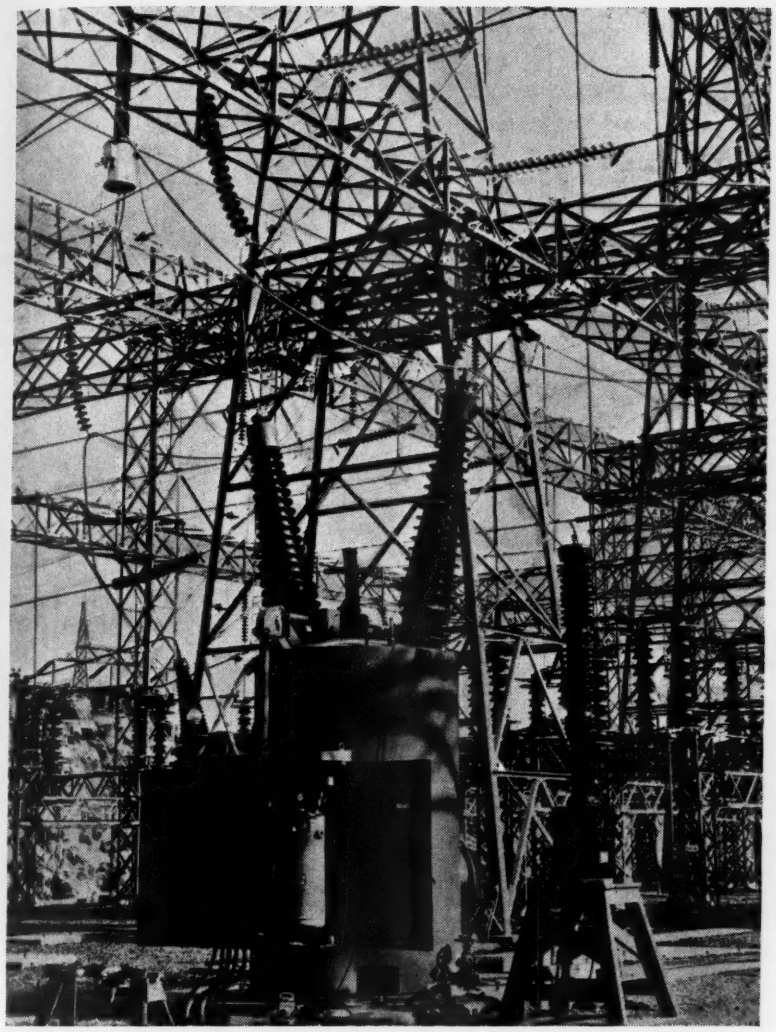

How to Keep a Name **STRONG**

Names in business can lose strength and vigor, even as you and I. Yes . . . a business can die, just like people. Here are ways business insures against this end:

Research for product improvement and new development . . . plant improvement for more efficient, lower cost operation . . . quality control to maintain standards of production . . . student and employee training to energize and revitalize the mental reservoir. Here's an example of how Research helps keep a business vigorous:

Grand Coulee and other mammouth hydro projects generating tremendous new pools of electrical energy, have created new problems in transmission. Through the great resources of its research department Westinghouse developed a new one-piece, oil circuit breaker to handle these immense capacities.

To test it, the U. S. Bureau of Reclamation routed the short-circuit output of the six, 108,000-kva generators at Grand Coulee Dam together with the back feed over six, 230-kv transmission lines from the Bonneville Power Administration system and the Northwest Power Pool for a tremendous short-circuit test.

The result: interrupting-capacity ceiling raised from 3½ million to 7½ million kva.

Research, plant improvement for efficient production and quality control are all dependent on another basic element . . . training.

Let's look more closely at that element . . . as it is handled by Westinghouse. Engineering Graduates who join us first receive some months of basic training . . . an orientation period with initial work assignments and product conferences. Then further training with specialization in engineering, manufacturing, sales or other activities. Finally, placement.

That is one of the ways an organization is kept strong. It requires strength to protect a name whose reputation is staked on the commitment . . .

YOU CAN BE **SURE** . . IF IT'S Westinghouse

tech engineering news

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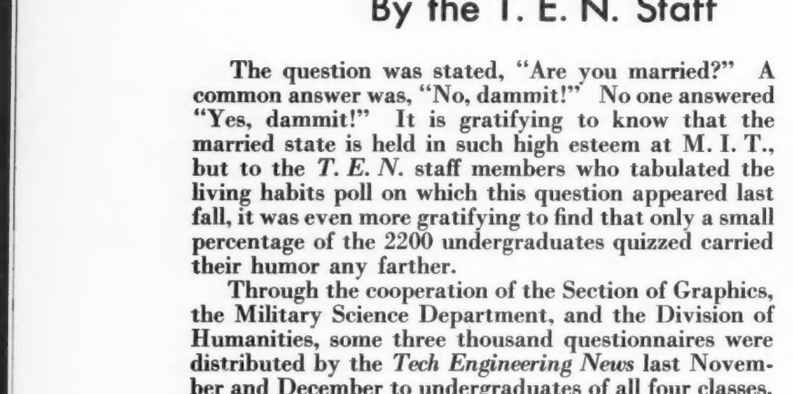
what did you do last week?

The Results of T. E. N.'s *Student Living Habits Poll*

By the T. E. N. Staff

The question was stated, "Are you married?" A common answer was, "No, dammit!" No one answered "Yes, dammit!" It is gratifying to know that the married state is held in such high esteem at M. I. T., but to the *T. E. N.* staff members who tabulated the living habits poll on which this question appeared last fall, it was even more gratifying to find that only a small percentage of the 2200 undergraduates quizzed carried their humor any farther.

Through the cooperation of the Section of Graphics, the Military Science Department, and the Division of Humanities, some three thousand questionnaires were distributed by the *Tech Engineering News* last November and December to undergraduates of all four classes.



Aside from entering into organized athletics such as this, Tech students engage in a couple of hours informal exercise each week.

Individual questions on these poll sheets ranged from, "Do you avail yourself of the swimming pool?" through "How many times a month do you attend church?" to a complete breakdown, by hours, of the time a student spent in a number of common activities each week.

In tabulating the results of this poll, random selections were made of from ten to twenty per cent of the poll sheets in a desired group and results calculated on the basis of these sheets. Where random selections included more than 100 sheets, reasonable credence was attached to the results obtained. Three major breakdowns were made by random selection from sheets handed in by 420 freshmen, 360 sophomores, 650 juniors, and 700 seniors. In a school where statistical analysis is a common course of study, the manner of obtaining the results to be stated may be open to criticism, but in the main, the results are accurate with regards to checks with available information.

In general, the largest item on a student's time chart is sleeping — some fifty hours of it each week. Although this value is not quite that which Dean Pitre has recommended to incoming freshmen, eight hours, it is not as little as the expressions in first hour classes indicate.

Studying takes up, on the average, twenty-nine hours a week; it would be rather impractical to attempt to put study on a so many hours per day basis, since the variation is probably extreme. There were some individual cases noted in which studying took five hours out of each week, and a few in which the work required ninety. Such data would have been disregarded as the work of jokesters were it not for the fact that every other answer on the questionnaire fit with this datum. Such a criterion as this was used in separating the wiser gentlemen (and there were about three per cent) from the majority. All those papers in which sleeping time was lumped in with class time, for example, were disregarded.

At this point, it should be emphasized that all the values for hours spent in each activity are actually students' estimates. Perhaps study time is generally overestimated and sleeping time under, but as a guess, fifty hours of sleep each week is probably not too low and twenty-nine hours of study is not too far from the registrar's standard.

About four and one-half hours per week of the Tech man's time is spent on his less than two extracurricular activities. If each undergraduate were active in two activities, there would be enough manpower to satisfy the most staff-hungry groups on the campus, but a more realistic picture of the situation is probably afforded by the value of only slightly more than two hours per person per week per activity — and this value is higher than it would be because of the few who were able to admit to more than ten hours per week. (Several went as high as thirty.) At a rough guess, about fifteen per cent of the students answering this poll section admitted that they were engaged in no outside activities. There were some, however, who put down numbers such as one and one-half, although it is difficult to see a means for engaging in half of an activity!

By way of other activities, exercising for enjoyment or health, at a rough approximation on the basis of 150 juniors and seniors, occupied over two hours each week. It was found, by a more accurate determination, that at one time or another 70 per cent of the undergraduate body uses the swimming pool, about thirty make some use of the sailing pavilion, and thirty avail themselves of the tennis courts.

The value for churchgoing among undergraduates, in attendance per month, may surprise some and disap-

Although not that number are members of the sailing pavilion, *T. E. N.*'s living habits poll indicates that thirty per cent of the student body use the pavilion at one time or another.

point others, being about one and a half times a month. Almost all of the church attendance was reported by persons who attended church four to five times a month, the remainder, and necessarily a majority, reporting no attendance at all, sometimes being emphatic about it. One person stated that his church attendance was proportional to his quiz averages but did not state whether the ratio was inverse or direct.

In Table I, the answers to various questions are given as broken down by year.

TABLE I

Freshmen sampled: 140 or 18.8% of total
Sophomores sampled: 180 or 20.1% of total
Juniors sampled: 210 or 20.2% of total
Seniors sampled: 298 or 25.4% of total

Question	*Frosh*	*Sophs*	*Juniors*	*Seniors*
7	1.6 activities	2.0	1.7	2.1
12	1.9 times/mo.	1.7	1.25	1.7
13a	27 hours/wk.	26	30	28
13d	4.55 hours/wk.	4.75	4.75	4.15
13f	50 hours/wk.	not determined	51.5	51.5
13k	5.6 hours/wk.	6.9	8.2	8.7
10	84%	86%	88%	86%
11/10	23%	20%	42%	60%
9	5.0%	31%	61%	81%

Apart from the need of identifying the numbers in the column headed Question, there are certain relationships between year of schooling and time spent on activities which ought to be pointed out.

Question 7: "In how many Institute extracurricular activities, including organized athletics, are you engaged?" Probably the only safe conclusion to be drawn from the results to this question alone is that juniors and freshmen have less time and/or interest in activities on the campus. It must be admitted that the freshman schedule is a shocking one and that in November when the poll was administered the shock may not have worn off. With regard to juniors, there is a group, probably of juniors, which holds that the junior schedule allows the least free time of any in an engineering curriculum.

Question 12: "How many times a month do you attend church?" It may be noticed that here again juniors are low, perhaps another reflection of lack of time. However, the high value for the Class of '53 can indicate that the customs of home are still fresh in the freshman mind but will be forgotten as time goes by.

Question 13a: "How many hours last week did you spend studying school work?" This question and all others asking for data in hours were stated so as to give a definite basis for an answer, i.e., the past week, and the questionnaires were distributed to avoid any big weekends such as the Junior Prom.

Juniors are definitely high in study time. An approximation made on the basis of answers to this question and one asking for class hours shows that their sum runs to about 55 hours per week, slightly over the average value taken from the Catalog.

Question 13f: "How many hours last week did you spend sleeping?" Apart from the inevitable wiseguys, answers here rarely overstepped the bounds of six hours on one side and eight on the other per night.

Question 13k: "How many hours last week did you spend on planned social life such as dates, outings or dances?" Here we have certain proof that the freshman in November has not found his way about. The increase in social life with time is definite but shows a leveling off between junior and senior years, a leveling off which might not be unexpected.

Question 13d: "How much time did you spend last week in extracurricular activities connected directly with school or your living group?" The values sound plausible if nothing else.

Question 10: "Do you work for pay during the summer vacation?" About the only question here is "What happened to the fifteen per cent who don't?" The values given as 11/10 denote the percentage of those working during the summer who work in jobs related to their professional course at M. I. T. The dip in the sophomore year is unexplained.

Question 9: "Do you belong to your course's professional society?" These values might be higher if all courses had professional societies.

A breakdown of the information gleaned from the living habits poll by class alone is only a part of the story. Necessary also are results of a study of dormitory, fraternity and commuter living groups. The results of such a division follow rather well as expected. Dorm men are low on church attendance, high on number of activities. Commuters are high on church going (many live at home — compare with value for freshmen), low on activities and hours spent on them. Fraternity men are high on social life and up with the commuters with regard to church.

As Table II shows, although fraternity men are involved in fewer activities than dorm men they spend more time on them. Unless house activities are counted in the hour total (they are not excluded by the statement of the question), this would show that this group puts twice as much effort into extracurricular activities as their nearest competitors. That commuters spend so little time on activities at school is readily understandable. Although fraternity men travel for only half as much time as commuters, even this amounts to forty minutes a day. The results given under working for pay can only be construed as a measure of the number of students in each group who work for pay — it would be senseless to say that any given fraternity man works an hour each week.

TABLE II

Dormitory residents sampled: 173
Commuters sampled: 181
Fraternity men sampled: 135

The samples were taken from all classes in proportion to the size of the class.

Question	*Dormitory*	*Fraternity*	*Commuter*
Church	1.3	1.8	1.8
Study	29.5 hrs./wk.	29	31
Social	6.5 hrs./wk.	8.9	6.6
Activities	2.3	1.9	1.1
Hrs./activity	2.0 hrs./wk.	4.0	1.7
Travel to and from M.I.T.	....	3.4 hrs./wk.	7.8 hrs./wk.
Working for pay	1.8 hrs./wk.	0.7	2.3
Hobbies	4.0 hrs./wk.	2.7	4.6

In spite of such appearances, Tech students are not as sleepless and hard worked as they think they are.

The results derived from a breakdown of veterans and non-veterans also give logical results — veterans get less sleep, study longer, and attend church more often. They engage in fewer extracurricular activities. In line with this, one might expect a veteran's social time to be lower than that of non-veterans, but the slight difference turns out to be in the other direction. The results given in Table III were taken from answers given by members of the junior and senior classes only.

Certain other data were obtained from less accurate studies of poll sheets broken down by course and cumulative. (One fact worth noting is that, although those who answered questionnaires were cooperative in giving values for everything else, a good many drew the line at putting down their cumulative rating, about eight per cent, even though they were not asked to identify the paper with their names. One stated "personal question" in the space allotted for rating. Perhaps this reaction is a reflection of the intense competition with regard to grades that is said to be prevalent at M. I. T.)

A breakdown of the larger courses, where a fair-sized sample could be obtained was made for the junior and senior classes and turned up some interesting facts. For example, according to their say-so (the only basis for the poll) Course IV seniors, both Architecture and City Planning averaged together, are having a rough time of it. According to the Institute's Catalog, fourth year students in this course are scheduled for about fifty hours of work, but according to answers on poll sheets, a value of seventy hours of class and study is more honest. (A discussion of this result with one student in this category revealed that the results of the poll are probably right, but Architecture students have a proportionately greater interest in their work — Ed.) Along with this estimate are estimates of forty-five hours of sleep, five hours below par, and four hours of social life, four hours below par, made for the same group.

TABLE III

Veterans sampled: 112
Non-veterans sampled: 113

Question	*Veteran*	*Non-veteran*
Study	31 hrs./wk.	29
Sleep	47.5 hrs./wk.	51.5 hrs./wk.
Social	8.6 hrs./wk.	8.0 hrs./wk.
Church	1.7	1.2
Number of Activities	1.6	2.1
Hrs./activity	2.5 hrs./wk.	2.2

On a more firm basis is the conclusion, based on a study of the returns from over 20 per cent of Course XV juniors and seniors, that these men spend thirteen hours each week on planned social life, four and a half hours above average for the junior and senior classes. No other course can make this statement. The nearest runner up found is Course III, which, on the basis of half of its senior class, runs a mere nine plus. When such an increase in one time-consuming activity occurs, it is proper to ask what loses out when one thing gains. This question cannot be answered on the basis of the poll as taken, since there are about thirty hours each week left unaccounted for on a given questionnaire and the total number of hours accounted for is not constant from person to person.

A study of 300 juniors and seniors divided into five groups by cumulative did not produce many definite results. Social life remained fairly constant among the groups; but there was a decrease of about four hours in study time in the high cumulative groups which comprised in effect the first and second Dean's Lists. Higher values for extracurricular activity hours were also found in the higher grade divisions.

When the poll sheets came in for tabulation a cursory glance showed that several questions would not be worth tabulating. Among these questions was one asking the amount of time spent consulting with faculty members. A check of about 100 juniors and seniors, who should have higher values for this question than the lower classmen, revealed that consulting with faculty members took up a mere twenty to thirty minutes a week, if that.

student-faculty committee

What It Is Doing For You

By Robert P. Donovan, '52

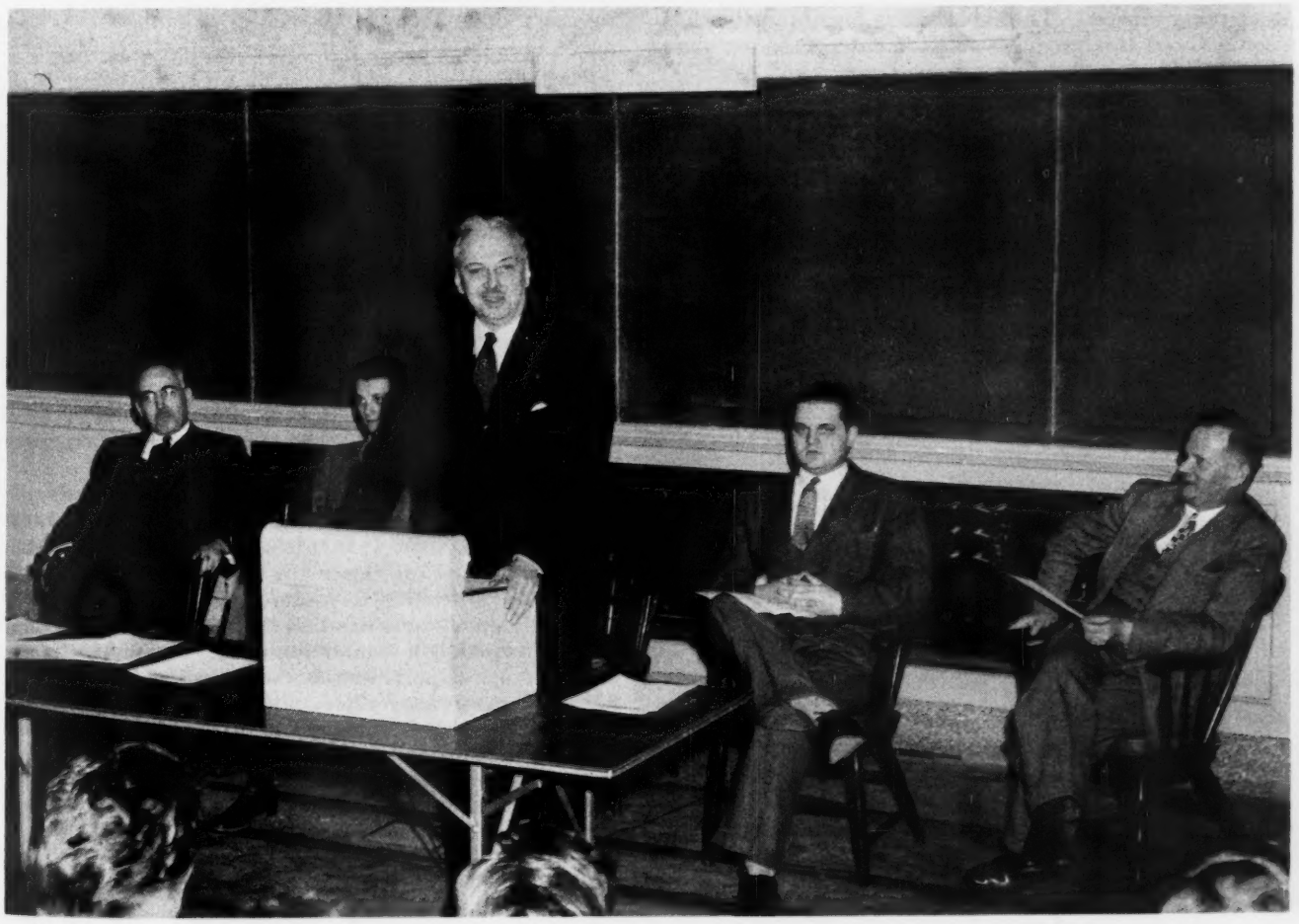
Dean Pitre buried his face in his hands, Professor Sears smiled grimly, and Admiral Cochrane shook his head heavily from side to side. These faces mingled with those of other professors of note, each equally pained, were in sharp contrast to the younger, brighter faces of students that now beamed in triumph. What great business had these men been deliberating? What matter could be responsible for such a dramatic scene? It is anyone's guess, for such a scene is commonplace at every Student-Faculty Committee dinner meeting.

Officially a sub-committee of the Institute Committee, the Student-Faculty Committee is classified as a part of Tech's student government. Actually it is much more, for the exchange of ideas and views and the influence of mature attitudes that is present at all dinner meetings make this committee as prolific a source of education as any classroom at Tech. The excellence of style and argument and the thoroughness of the thought cannot but impress and be absorbed by the participating students.

The committee does more, however, than sit around and fill the atmosphere with polished rhetoric. The past year has been a particularly active one — one in which many new projects were experimented with. Among these projects is the Student-Faculty Forum, where questions of great pith and moment to both students and faculty are hashed out. At the first forum, entitled, "How Can the Quality of Instruction Be Improved at M. I. T.?," Dean Harrison, Dean of the School of Science, Dr. Mueller, Professor of Physics, Gordon Raisbeck, freshmen calculus instructor and graduate student, and Jim Jensen, undergraduate, formed a representative cross section of interested parties. Each presented his ideas on the subject in a brief talk and then threw the discussion open to questions and opinion from the audience. If no direct benefits came from this discussion, certainly it did open everyone's eyes to the fact that all three groups of the M. I. T. family, the faculty, students and administrators, are working toward the same goal — the best teaching possible for Techmen.

The second forum posed as its question, "Too Much Emphasis on Quizzes?" Professor Sears and Bob Briber from the committee along with Professor Fano and Tom Hilton gave the opinion of the quiz maker,

Dean Burchard speaking at the first Student-Faculty Forum held at M. I. T.



the quiz giver, the senior quiz taker, and the freshman quiz taker.

On February 14, the question was "Is Your Instructor Conscious of You?" The purpose of the forum was to create closer and friendlier relations between instructors and students.

As this article is being written plans for another forum are being formulated. Other likely questions are, "What Price Better Laboratory Periods?" or "Brown Bagging vs. Activities." Why not drop around for this next forum and see how things stand or better still let the committee hear some questions you feel would make good forum topics?

Tangible results of the first forum on improving the quality of teaching are the teaching seminars that were held early in the term mainly for the new and younger instructors. The course is composed of four one-hour seminars. Professor Walter Whitman, head of the Chemical Engineering Department, led a seminar on "The Broader Aspects of Teaching"; Professor John Slater, head of the Physics Department, "The Practical Details of Teaching"; Dr. Alex Bavelas, Assistant Professor of Psychology, "The Psychology of Teaching," and Dean Durrell of the Boston University School of Education led the final seminar on the "Teaching Profession." The idea behind this series of seminars was to give new instructors some idea of what to expect and some advice on how to start off on the right foot with their class.

The visitation program established in the fall of 1949 among the faculty and still in effect has the same goal in mind. This program assigns to each new instructor an older, experienced professor who serves as an adviser by dropping in on his fledgling's classes and informally offering his suggestions and criticisms afterwards. Any glaring faults or shortcomings can be pointed out without giving offense. The faculty has been quite enthusiastic about this program and some departments plan to install it on a permanent basis.

To accompany all this advice and guiding that one faculty member gives to another are the faculty evaluation polls, in which the students rate their instructors. These polls were conducted in nine of the Institute's twenty departments last spring with the purpose of giving the instructors a picture of themselves the way their students see them. Most faculty members approved of the idea enthusiastically, attributing real value to the program. With the experience gained and suggestions submitted, the next faculty evaluation poll should prove more reliable, and more concise.

The principal aim of the committee is to cultivate much closer student-faculty relations. Too many Techmen feel that the instructor is the champion of an imaginary opponent, possibly McLaurin's Monster, who must be defeated by any means whatsoever or if not actually defeated, he must always be reckoned with as an enemy. The committee would like to replace this attitude by a coach-player relationship. No team wins a championship when they fear, dislike, and fight with their coach. The same is true in the classroom. An instructor must be a coach in whom the students have full confidence and respect. When you feel something is wrong with the method of teaching — the style of coaching — you must act as athletes do — tell the coach, not everyone but him. Up to now the Student-Faculty Committee has served as an intervener between the students and faculty by investigating and reporting all complaints and grievances to the faculty. It is looking forward to the day when this sleuthing will be unnecessary — to the day when the players of the Tech team talk freely with the coaches.

To promote just this the Institute has given Room 2-290, now being remodelled and furnished, to the committee. The room will be used as a pleasant gathering place for student-faculty teas, discussions, and bull sessions. Anne Rosie, a coed senior in Architecture and a member of the committee, has undertaken this job of remodelling as her term project. The present plans call for the completion of the room sometime in April.

The policy regarding this room is that only students accompanied by at least one faculty member will be granted its use. Once admitted, however, they will have use of the food and refreshments always in stock in the room's kitchen, providing of course that they agree to leave the room in the condition they found it. The room will be kept locked and opened only on request, except for the hour between five and six each week day when there will be a student member of the committee in attendance.

The highlight of the committee's regular work is the monthly dinner meeting. Usually held at the Silver Room, Campus Room, or in a nearby hotel, it begins with a very satisfying meal, after which the business of the evening is discussed. The agenda for these meetings is drawn up by the student members of the committee at a previous student meeting. It is here that any problems or suggestions gleaned by the members are brought forth and weighed. Those that qualify become agenda topics and at the following dinner meeting the faculty hears of them and is asked to comment about them.

Among the current problems and projects is the idea that independent student-faculty committees established in each of the Institute's large courses would be a big step toward the closer student-faculty relations the committee is seeking to promote. The Chemical Engineering Department has had such a committee for two years now, while a similar committee in the Mechanical Engineering department is commencing its first year. Other departments whose size and situation warrant the institution of similar committees are Civil Engineering, Electrical Engineering, Physics, Chemistry,

An impromptu meeting of the committee.

Business Administration, Aeronautical Engineering, and Mathematics.

The function of these committees would be mainly to handle gripes that arise in their departments, but there is nothing to stop them from making many constructive suggestions and improvements and help the course positively. Course X's student-faculty committee tells of having helped students obtain summer employment and rendered valuable assistance to many in their thesis problems.

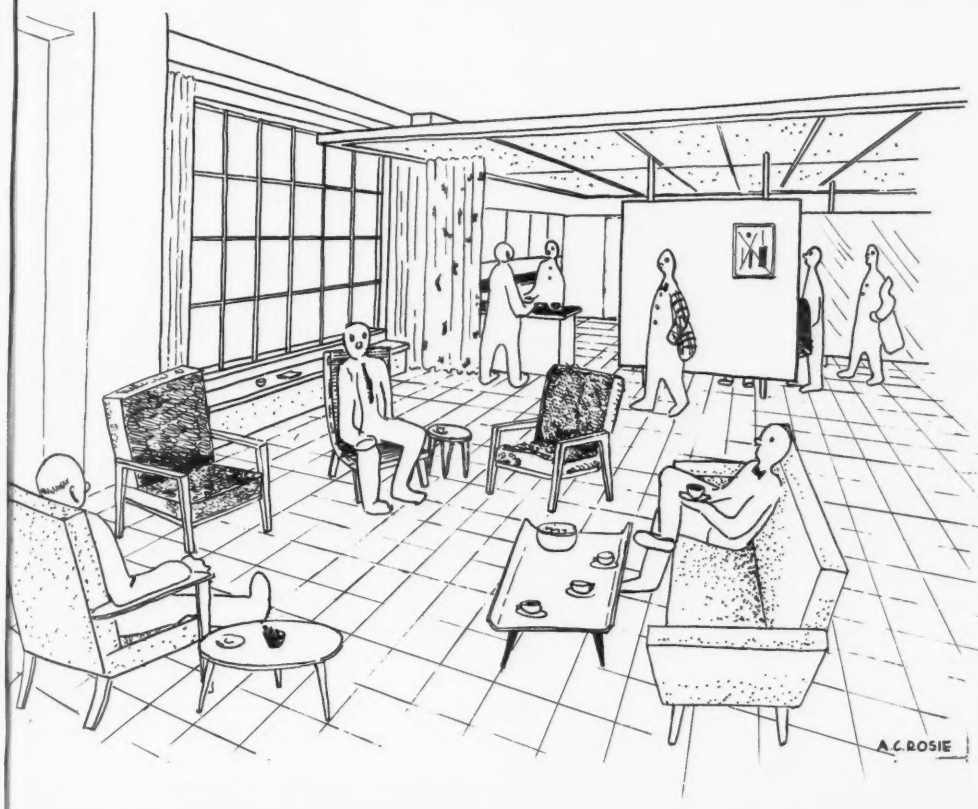
Another current topic in the minds of committee members is the creation of brief courses in notekeeping, reading, slide rule technique, etc. to be quite similar to the seminars sponsored by the T. C. A. in M11. On the average a person reads from two hundred to three hundred words per minute; but after finishing a reading course similar to the one the committee is thinking of creating, he jumps to five or six hundred words per minute, usually with better comprehension. Rapid comprehensive reading is important not only at school but for the rest of our lives. There are few among us who could not benefit from such a course. The same argument could be offered for other basic skills where the difference between good and excellent pays off many times in the long run.

Whenever special problems arise, the committee usually supplements its own opinion with that of men who are particularly interested in the subject. At a recent meeting in which the honor system and Tech was on the agenda, Tom Hilton, Art Wasserman, and Wes Haywood, each of whom is greatly interested in the matter and each of whom had been working independently on it in one way or another, were present as guests. During the course of the evening's discussions, they discovered that they were working for the same thing; and they, with several committee members, formed a group that is now busy developing practical plans for an honor system at Tech.

A few years ago word reached the committee that the women's bathing suits distributed at the swimming pool were definitely not flattering — indeed flattening — to the figure and consequently many female bathers were much less anxious to go swimming than normally should be. Although the matter seems trivial, the committee took up the interests of the Tech coed and secretaries only to be informed that the sanitary code required the wearing of these bathing suits and that was that.

To bring a problem to the attention of the committee you merely have to contact one of the members and tell him the facts of the case. He will call the attention of the rest of the committee to it who in turn will decide just what is to be done about the problem. In the likely situation that you know no one on the committee, you may always drop a note in the Student-Faculty Suggestion Box by the door across the hall from the Cashier's Office. All messages, burnt-out matches, and cigar butts are removed weekly. The committee urges you to settle any problems you can with the involved parties personally; but in the event you feel you cannot, do not hesitate to contact the committee. With the opening of the Student-Faculty Lounge, a student member will be in attendance from five to six o'clock every week day. Drop in with your problems and suggestions or just drop in and have a look around.

In the President's Report of 1949 Dr. Killian says "another example of the healthy condition of our student life at the Institute is the development of closer student-faculty relations and the creation of better opportunities for the two groups to work together for common educational goals." It is that very end that the Student-Faculty Committee has been working for for some time now and although the ultimate goal is far from sight, this quotation from Dr. Killian indicates that the committee is making progress.



An architect's drawing of the new Student-Faculty lounge room

traveling-wave tubes

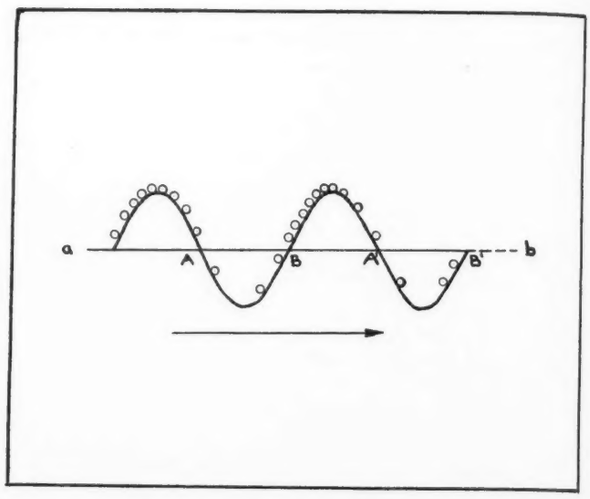
New Tool for Ultra-High Frequency

By Robert P. Redick, '53

It has been known for some time that a most serious obstacle to the extension of the high-frequency limit of tube operation is an apparent necessity to use resonant circuits or wave-guiding structures of smaller and smaller dimensions as the frequency is increased. This requirement arises from the fact that the tube structures have to be arranged so that the kinetic energy of electrons can be efficiently converted into the energy of the high-frequency electric fields which are supported by these structures. This reduction in tube size leads to a reduction in useful power when maximum emission current density on the cathodes is approached. These fundamental considerations made it extremely important to search for new methods of amplification and generation of microwave energy.

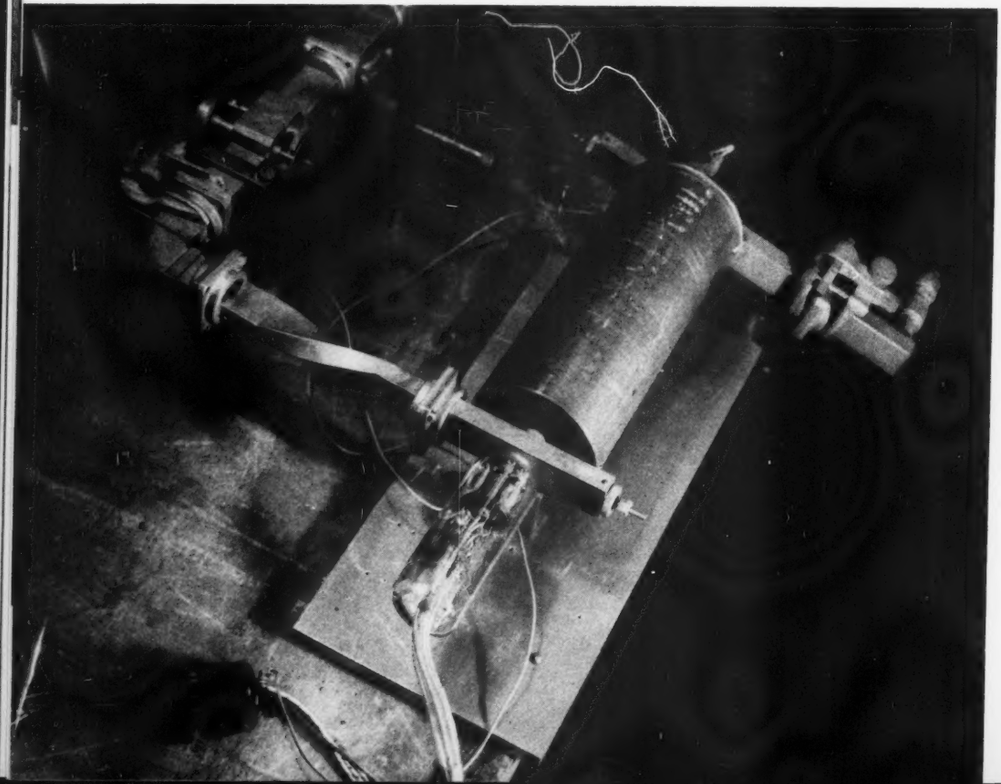
In 1942, Rudolf Kompfner at the Clarendon Laboratories, Oxford, England, felt the need for a method which might overcome the difficulties then facing a tube of the klystron type when operated as a high-sensitivity amplifier at microwaves. One of the chief difficulties was connected with the transit time of electrons crossing the "working" gaps by means of which the electron beam in a klystron is energy-modulated, or by means of which energy is withdrawn from the beam.

A number of conflicting requirements made it inevitable that the energy transfer in such gaps would be considerably reduced, so it was a natural and perhaps obvious thought to inquire whether the energy transfer between an electron beam and electric fields traveling at the same rate as the electrons could be made more efficient than the energy transfer obtained in a klystron gap. In designing a tube with these ideas in mind certain principles had to be adhered to. For practical reasons, it is desirable to keep the accelerating voltages on an amplifier tube below a few thousand volts. As



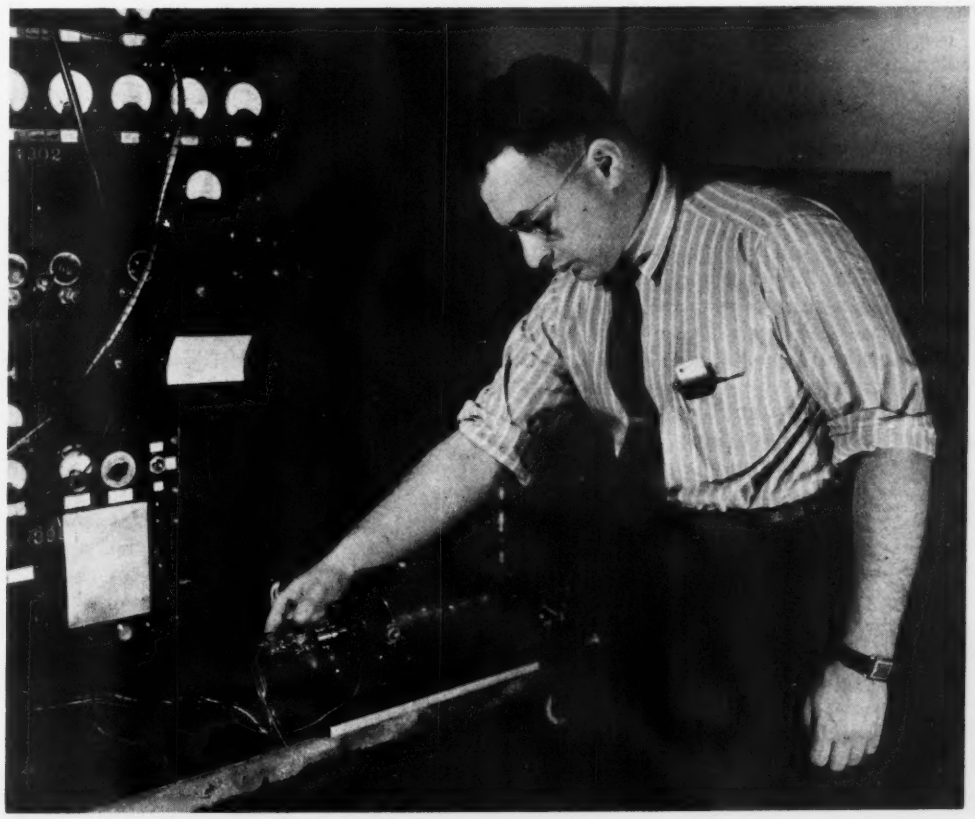
electron velocities at these voltages are small as compared with the speed of light (about one-tenth), it was necessary to find a means of slowing down radio-frequency waves to velocities almost synchronous to that of the electrons. Several types of waveguides which would propagate such slow waves were known, but the one that proved most useful was the helix. It combined good coupling to the electron beam with very low dispersion, and it was relatively easy to build. Further research and experimentation lead to the development of the "traveling-wave" tube as it was first presented by Kompfner.

The traveling-wave tube consists of a helical (cylindrical) coil which, in the absence of an electron beam, is



This photograph shows a traveling-wave tube within its magnetic focusing tube.

capable of supporting an electromagnetic wave along the axis of the helix with a phase velocity substantially less than the velocity of light. Such a wave may travel in either direction. When electrons are shot through the center of the helix, they are alternately accelerated and decelerated by the field of this wave. It is found that in the presence of this electron stream the wave traveling against the electron motion is little affected, but the wave traveling in the direction of electron motion is broken up into three components. For a lossless helix, one of these forward waves is attenuated, one is unattenuated, and a third increases in amplitude as it travels, or has negative attenuation. On the average, the electrons travel a little faster than the increasing wave travels. In the course of its traveling the input signal produces a wave on the helix and consequent "bunches" in the electron stream. These are made to increase, or are amplified, as the electron stream moves past the mixed wave of electromagnetic field and charge density, and interacts so as to reinforce this wave.



L. D. Smullin, who is carrying on much of the research at M.I.T. on traveling-wave tubes, is here removing one from its associated apparatus.

The electrons forming a given bunch are continually changing, for the electrons travel faster than the wave and pass through the bunches. If we examine the motion of the electrons past an increasing wave, we can easily see why they give energy to the wave. Suppose we move with the wave propagated down the helix, so that the crests and the troughs appear to be stationary. As the electrons go a little faster than the wave, they will move slowly past us to the right (the direction in which we and the wave are moving). The electric field, which we observe as stationary, may be regarded as a series of rises and falls in electric potential; as an analogy we may replace the wave by a series of sinusoidal hills, shown in the figure, and regard the electrons as a stream of frictionless balls rolling to the right along this series of hills. The electrons (balls) will go slowly at the tops of the hills and swiftly in the valleys.

Now, imagine for a moment that the wave was not increasing as it traveled along the tube. Then, as we traveled with it, the heights of the hills and the depths of the valleys would not change with time. Suppose we consider motions of electrons between various mean points of the wave lying along the center line *a-b* of the figure. In leaving *A* and falling down into the valley, an electron gains just as much speed as it loses in rolling up to *B*, which is on the same level as *A*. Thus, electrons at *B* travel with the same speed as electrons at *A*. Similarly, an electron in going up from *B* loses just as much speed as it gains again in falling down to *A'* and thus the electron stream has the same speed at *A'* as at *B*. Suppose, as is actually the case, that the wave increases as it travels. We, traveling with it, merely see it growing larger with time. Now, an electron falling down from *A* falls down a small slope, but goes up a steeper slope in reaching *B*, for all the slopes have increased between the time the electron leaves *A* and the time it reaches *B*. Thus, the electrons at *B* move slower than the electrons at *A*. Similarly, an electron going away from *B* climbs less of a hill than it falls down in going to *A'*. Thus, electrons are going faster at *A'* than at *B*. We see that, when the wave is increasing, the electrons go slow on the up slopes and fast on the down slopes. Where the electrons go slow, they are nearer together; where they go fast, they are further apart. Thus, the electrons are bunched on the up slopes. If we now stand still with respect to the wave, we see that these bunches are really moving rapidly in the opposing field regions of the helix, and the energy they give up serves to make the field grow as it travels along.

We have already seen that, for a wave of constant amplitude, the electrons have the same speed at *A*, *B*, and *A'*, but they go slow at the crests of the wave and fast in the valleys. The bunches so produced do no work against the field; they do, however, serve to change the speed of the wave, and a careful analysis

(*Continued on page 22*)

reality

Part Two

By Rudolph William Preisendorfer, '52

Rudy and Joe, two outspoken space engineers, are manning an automatic observation-calculator outpost stuck in the middle of exactly nowhere. Calculator number five has been making odd sounds while carrying its usual load of information and conclusions about a corner of space, but there is nothing out of order in its mechanism. The same load switched to other calculators produces in them the same symptoms. This is a new one to the engineers and has caused them no inconsiderable worry.

One breakfast-time nothing tastes right. Joe gets up from the table in disgust, screams, and falls to the floor. When he recovers, "The walls . . . the walls folded in, Rudy, didn't they, didn't they?"

"Yes they did, Joe."

I turned and looked at the walls again . . . they were steady now. "I think we had better call Base, Joe. This thing's getting too big."

"Yes," he answered.

"Here, let me give you a hand." I extended my hand down to him and pulled him to his feet. He was as white as a baby Nova, and just as unstable. I didn't feel too well, either. "Come on, we'll get this damn business off our chests, and spill it to Base."

"Nothing has ever happened like this before, Rudy."

"No, it hasn't, but as the trite saying goes, 'There's a first time for everything.' "

"But we've got everything figured out. We are at a point now, where civilization has found out everything about the universe. There is nothing left for us to do now, except pick up verification data for the Base . . . something like a sinecure . . . if you look at it . . . isn't it? The math has been worked out for everything . . . everything. We know the universe backwards and forwards right down to the last cubic millimeter . . . our machines are supposed to be flawless and self-operative . . . we're just dummy variables in this outfit . . . placed here on that remote almost nonexistent chance that something might need human attendance."

"Well, this is that one shot in a billion, Joe . . . and we got it right in the neck." I paused and let his words sink in. There was something radically wrong in a universe, a place where we had anticipated all things that were going to go wrong, and automatically corrected them as we went along.

Joe brushed himself off, and led the way to the communications cubicle. We entered it and I sat down at the transmitter. I primed the circuits and punched in Base's numbers from memory. Joe flipped the overhead switch that would activate the dead pickups outside and increase antenna spread.

"Okay," he said.

I flipped on the automatic caller. The panel light winked each time a cycle call was completed. It took only about ten point two seconds to call Base from where we were. Base was about thirty-seven light years away, towards the hub of the Base galaxy. The panel light winked for the tenth time, and we both leaned forward, anticipating the reply light to glow. The transmitter light winked for the eleventh time . . . the twelfth . . . it kept on winking . . . the reply light stayed dead.

Joe was making strangling sounds in his throat, and I could feel my forehead getting warm and my ears starting to burn.

"Cut it!" said Joe and he flipped the by-pass circuit switch.

"Want to try again?" I asked.

"Yeah, I want to set up the numbers. Seeing your atrocious display of absent-mindedness yesterday, I would put it past you to remember your age."

He took his turn punching in Base's numbers on the panel. I threw the overhead antenna spread switch for him, and he flipped on the automatic caller. The tenth cycle came and we started to wait again. The damn little light winked, I don't know for how long. We just sat there, each breaking out in his own peculiar form of sweat.

"Well, just don't sit there," I said, "maybe you have also forgotten the call numbers. You know, we seem to be both going to the dogs here. I suggest we look it up before we get a case of nerves no amount of Nimine will cure."

"I didn't clear the panel," he said simply. "I just cut in by-pass, but I didn't clear the board; I punched what I thought were the numbers, and each stud I activated, was already down . . . our value . . . we are either both right, or both wrong . . . it's mighty funny, though, having the same error locked into our brains."

While he was talking, I reached down the call number booklet and thumbed through the B's . . . I found Base and ran my finger across to the call numbers. They were the same as I had punched into the transmitter's panel. "We're right," I said, and handed the booklet down to him so he could view the numbers.

"Call Mirabel," I suggested. "It's a little farther out than Base, but it is in Base's general vicinity. Maybe something's wrong with their receivers."

"All interlocking twenty of them?" he asked with a grimace. "Something had better be really wrong if that is the case."

Joe punched in Mirabel's call numbers and settled back. I sat down in a chair behind him and hunched forward so I could view the automatic cycle light. It winked eleven times and we started to tense . . . our attention went to the dead reply light. After the twentieth or so cycle, Joe slammed on the by-pass and leaned back in his chair and looked at me. I got up and said: "Joe, turn on Base's call numbers again, I want to check and see if the antennas are getting power. We can check by watching the pickup filter circuits in the bank control room."

"Check," he said simply, and with a sigh, he flipped on the automatic caller.

I ran down the corridor and skidded to a halt in front of the bank central panel. I looked at the pickup meters and noted that they were filtering out the transmitted call signals from the input circuits to the calculators.

I headed back to the control cubicle at a slow walk,

thinking deeply. I was walking along with my head down, and was watching my feet scuffle along the corridor floor between the rows of calculators. A movement caught my attention; I saw it out of the corner of my eye. I looked up, startled.

I must have screamed, and fainted, for the next thing I knew, Joe was hovering over me. . . . I was in my bunk and he had apparently given me a shot of Nimine to revive me.

"God, did you give me a scare," he said. "What's the idea of screaming your head off? You're not cracking, are you?"

"Did you see anything unusual while I was gone?" I forced out the words as calmly as I could.

He paled. "Do you mean something like in the kitchenette just a few minutes ago?"

"Yes," I forced it out.

Joe compressed his lips and looked at me, but did not continue.

"Joe, I saw it too out there, in the bank room. I was walking along coming back from the panel, and trying to figure out why Mirabel or Base wouldn't answer . . . our signals are going out all right. I thought I saw something out of the corner of my eye. I looked up and the whole room was swimming around. I felt sick . . . but I was sure that what I was seeing was making me sick, and not that I was seeing things because I was sick. The room looked as though I was viewing it through a sheet of turbulent water. The outlines of the machines were wavering, and they broke ranks."

"They what?"

"They broke ranks. They were walking around. They were muttering and groaning and walking around, they were not even noticing me, but rather just being unrestful . . . a couple of them disappeared when I looked closer at them in that split second before I conked out." He got even a little paler, and he settled himself slowly on the edge of my bunk.

"We can't just sit here," I said. "Let's try some more stations . . . say in our own belt hereabouts. We surely can't be alone in this madness."

"Might as well," he said with a sigh as he got up. "Feel okay . . . enough to walk back to communications?"

"Yes . . . give me a hand, will you?" I staggered in through the cubicles door right behind Joe. He took the call numbers booklet and placed it in his lap. He started to thumb through the book.

"How about SO-a/C-S-10997?" he asked.

"Right."

He punched in the numbers and flipped the automatic caller. It blinked once and the reply button lit up.

"Well! What do you know!"

"Get it, quick," I urged.

He flipped on the receiver and the station numbers were coming through clearly on the visor. The visor swam with a red and yellow streaked pattern indicating that it wasn't manned on the other end. Suddenly the pattern cleared, and the familiar face of the operator, Bench, filled the screen.

"Joe! Rudy! Jeez, it's good to see you! There is something rotten around here. We have been having troubles for the past twenty-four hours . . . everything is going haywire. . . . Jimmy is on the verge of cracking up and I haven't had a wink of sleep all the time . . . our banks are actin . . . "

"Hold on. Hold on . . . " interrupted Joe. "Slow it down to the speed of light, will you? And don't be an egotist . . . you're not unique as far as troubles are concerned."

"Huh?"

"You heard me, Rudy and I are having the same troubles, it seems." Joe wet his lips and continued: "Did you try to get hold of Base or Mirabel?"

"Yes . . . " Reception must have been very good, or the paling job on Bench's face must have been really something to see.

"Well?"

"Well . . . what?" countered Bench. "I couldn't get a rise out of either of them. We checked everything . . . we are sending, but nobody is . . . well with your exception . . . nobody is receiving. It is . . . it's just as if they weren't there any more to get our signals."

"Did you try to get any of the other stations in our belt?" This was Joe.

"Yes," answered Bench. "I got in contact with a whole block of numbers from 778 to 998 . . . that's you, and Rudy."

"Hmmm. And what did they have to say?"

"The farther I got out from Base, the less trouble they were having. . . . But each one was complaining of the same things we are experiencing now."

"How about the block of call numbers from 1 to 777?" Joe asked.

"No answer."

"Let's get away from that for a while," said Joe. He continued: "Did you say you were having troubles with some of your computer banks?"

"Yes . . . " Hesitation . . . "Yes, Jimmy found that our number five was acting up. He tried to find out what was wrong, and he opened her up. He had to climb inside to test the secondary circuits. . . . Something must have happened. . . . I found him all curled up inside of it this morning after I had gone out to look for him after I missed him at breakfast. I gave him a shot or two of Nimine . . . but he's still out like a light."

"How about you, Bench?"

"I was coming to that . . . give me a chance. I also noted that five was wrong somehow, and I tried like hell to figure it out. As far as I can see, there isn't anything wrong inside the station itself. . . . It is the material or something that is being fed into the machines."

"We found that, too," I added.

Bench continued: "As I was clearing her out yesterday, about halfway through my shift, I saw the strangest thing. The whole room seemed to waver and swim before my eyes . . . and . . . I don't know if you'll believe me . . . " he paused.

"Go on," said Joe, getting a little whiter.

"Well . . . " continued Bench. "For a minute or two I thought I was going nuts, the computers seemed to be waltzing around the room and jabbering away like mad . . . and most curious of all . . . the moment I really tried to focus my attention on . . . " He paused, probably seeing my ashen face through the screen . . . "So you had the same experience, Rudy?"

"Yes, Bench . . . they did a fadeout job on me too."

"The only thing that I can see," said Joe, "is that this whole mess is universal in scope and seems to have gone to extremes in certain portions of the galaxy."

"And did you notice just what portions of the galaxy, Joe?" There was a strange look on Bench's face.

"No we didn't get around to investigate it fully," answered Joe. "All Rudy and I noticed was that Base and Mirabel were not receiving or sending, and now, from you . . . as you say the whole bloc from 1 to 77 . . . why hell! I see it! The disturbance is radiating from Base . . . and is expanding in a spherical shell outwards. We are next in line from Base!"

(*Continued on page 28*)

the science of sails

The Study of the Mainsail, with Nature as a Guide

By Charles M. Saltsman, '52

Perhaps fifty centuries have passed since man first discovered that he could harness the force of the wind to move his tiny boats through the water. And until only a hundred or so years ago, apart from manpower, the wind has been the prime motivating force for every type of vessel. To the ancient seafarer, the principles behind this type of propulsion appeared quite simple. They had only to mount on their craft some sort of device to "catch" the wind and they would move, provided, of course, that they were willing to go in the same direction as the wind happened to be headed. These devices we know of as sails.

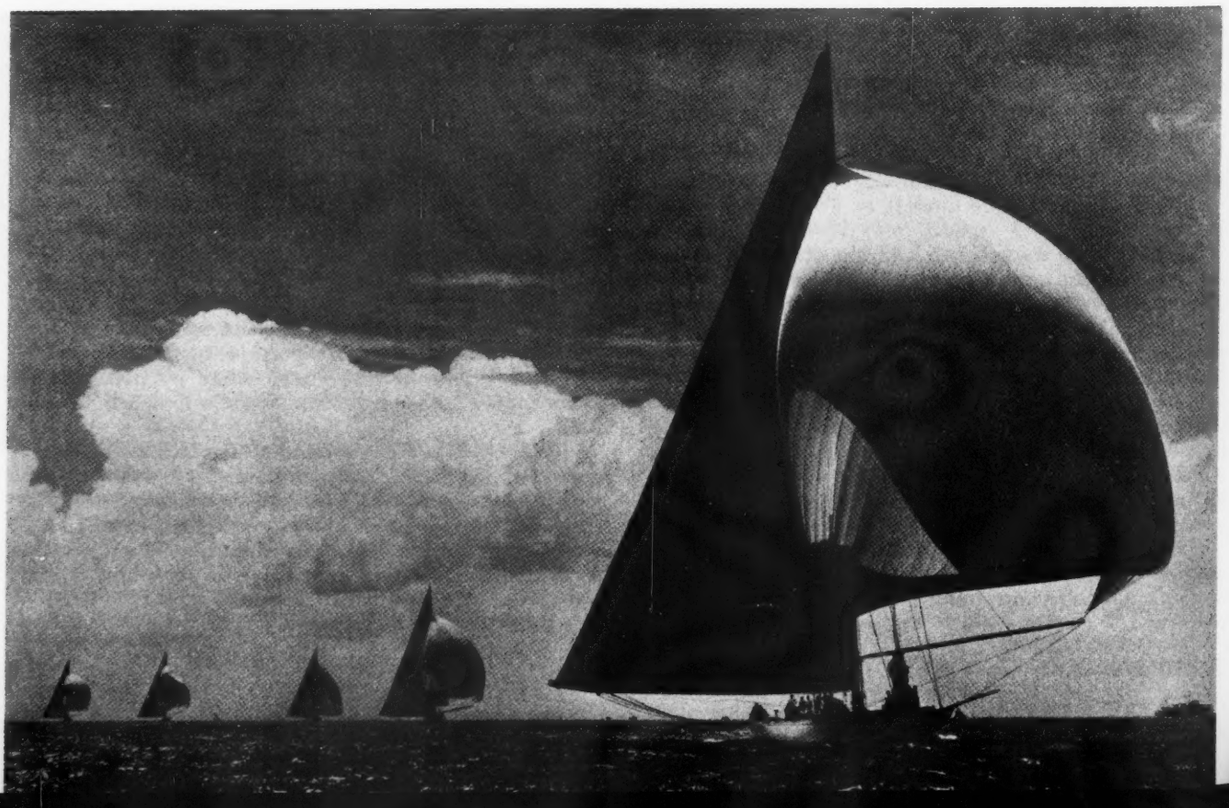
As time went on, and boats grew larger and larger, sails became more and more important. Men found that they did not have to go in the same direction as the wind: by setting their sails at different angles, they could move in different directions. And they found that by using more and larger sails, they could achieve greater speed. Yet these simple discoveries took a long time to develop; only fifty years ago, after steam had safely established itself as a more dependable means of power than sail, did man first begin to study the mechanics of the sail. This study, still far from complete, has led to widespread improvement in the design of modern sailing yachts, and has been of some value in the field of aeronautics.

Basically, the various rigs of wind-driven vessels are divided into two classes: fore-and-aft, and square. The latter started its decline with the advent of steam, and is almost non-existent today. But the former, the fore-and-aft rig, seems to be here to stay, if only to push the millions of tiny pleasure craft about. And hundreds of improvements on this rig are popping up every year.

Somewhere around the turn of the century, a few scientists came stumbling out of their dusty labs for a breath of fresh air and got interested in birds. So they began an exhaustive study of these feathered creatures to determine exactly what made them fly. This wasn't particularly new — others, who had dreamed of building flying machines had seen birds, had studied their construction and the way by which they were able to flap their wings. The flying machines were built, all of which flapped their wings with great gusto, and none of which flew. But the new study turned out to be something different. These enlightened fellows were going to fool around with force parallelograms and resultants. And to help them even further, they somehow decided to forget all about the flapping business, and to concentrate on the gliding end of the flying. After a few years of dissecting, arguing, figuring and drawing, someone came out with a marvelous conclusion: the best kind of a sail, with very few reservations, should be as much like the wing of a bird as possible.

At first this conclusion may seem somewhat erroneous, but a little study of the bird's wing, when in the gliding position, shows it to be true. For such a study, only the wings of the soaring birds, the albatross, gull, or buzzard, should be considered. These birds are able to glide because of the wind, which, striking the arched

J-Boats, the largest of all sailboats. Left to right they are: Yankee, Endeavor II, Endeavor I, Rainbow, and Ranger.



The square rigged "Joseph Conrad" is one of the few ships of her type still in use.

form of the wing, holds the bird aloft. (We assume that the bird is not moving, but rather, the air. All that matters is that one be moving relative to the other.) Perhaps the effect of the arch in the wing is best explained by first considering the wind blowing against a flat surface, end on. Two small, but not negligible forces tend to push the surface in the direction of the wind. The first is the push on the edge of the surface as the wind strikes it; the second is the friction force between the two. If, however, the surface is arched, a new force comes into play, one directed normal to the arch at its center. Now, as the wind seldom blows horizontally, but rather with an angle of about four degrees upwards, this normal force, in the case of a perfectly level, arched wing, is directed slightly forward, into the wind. If this force is now resolved into horizontal and vertical components, we find that the former tends to pull the wing into the wind, while the latter tends to lift it. A well balanced arch-shaped plate, in a strong wind may rise or move forward against the wind: exactly what happens in the bird's case. A careful observer will notice that birds always fly upward against the wind, never with it.

Further study of birds reveals that nature puts a good deal of importance on the length to breadth ratio of wings. This averages three to one, with the best soarers as high as five to one. Furthermore, the carrying power of the wing is greatly increased by increasing the amount of arch in the wings. Airplane designers are usually a bit wary of this, for increasing the arch decreases the stability. This is, however, unimportant in the sailboat.

Where does all this bird-lore lead us. Actually it gives us a good start on the study of sails, for while the angle with which the sail meets the air is just ninety degrees removed from that of the wing, the only result of this is that the four degree upward angle of the wind has no bearing on the sail, and otherwise the sail and the wing are exactly the same. It therefore seems to be the best policy to follow the laws of nature, and copy her designs. Of course we must make a few reservations: sailboats do not have to have their masts and rigging constructed to allow for flapping, nor must the sailboat be able to fold its wings in order to get into its nest. But the arch, the length to breadth ratio, and the aerodynamic properties of the two should be as nearly alike as possible.

This gives rise to the question of how to construct the perfect sail. Unfortunately, this is an impossibility. Gain one thing, and another is lost. For example, the ideal mast should have a uniform curvature from deck to telltale. But this makes reefing next to impossible. So the next best thing is to design the sail as a compromise of all the elements that should be there.

From our bird's wing, therefore, we may deduce that the shape of the mainsail (which is the primary driving sail) on a Marconi rigged boat should have a height of, say, about four times its foot, or length along the boom, and should be cut with a fairly full belly to give a good arch. (The best flyers among birds have a curvature of about one-fifteenth the breadth of their wings at the point of greatest curvature.) The luff, or leading edge, of the sail should have a uniform curvature. This has already been shown to be impossible, with the result that most modern masts are straight. A few European classes of boats carry masts which are bowed for about one-third of their length at the top. In addition to this, the sail should be so mounted that its surface will hold a uniform curvature throughout. This becomes somewhat of a difficulty where fastened to the boom or gaff. Here the sail is flattened, in most cases, with not inconsiderable loss of efficiency. Several types of booms designed to allow the sail to maintain its natural curvature are now in use. The simplest of these is a flexible spar, which will arch with the sail, although this may easily become a menace in a strong wind. Another, and perhaps the most practical device is an additional piece of sailcloth, the outer edge of which is cut to the proper arch. This edge is fastened to the foot of the sail and the seam reinforced with a batten. The inner edge is cut straight and bent onto the boom. When sailing, this additional piece of cloth forms a right angle with the sail; the latter is allowed to arch.

As for the gaff, while similar devices might be put into use, it has been pretty well established within the last decade that a boat rigged with the additional spar is far inferior to one with the high Marconi rig. Gen-

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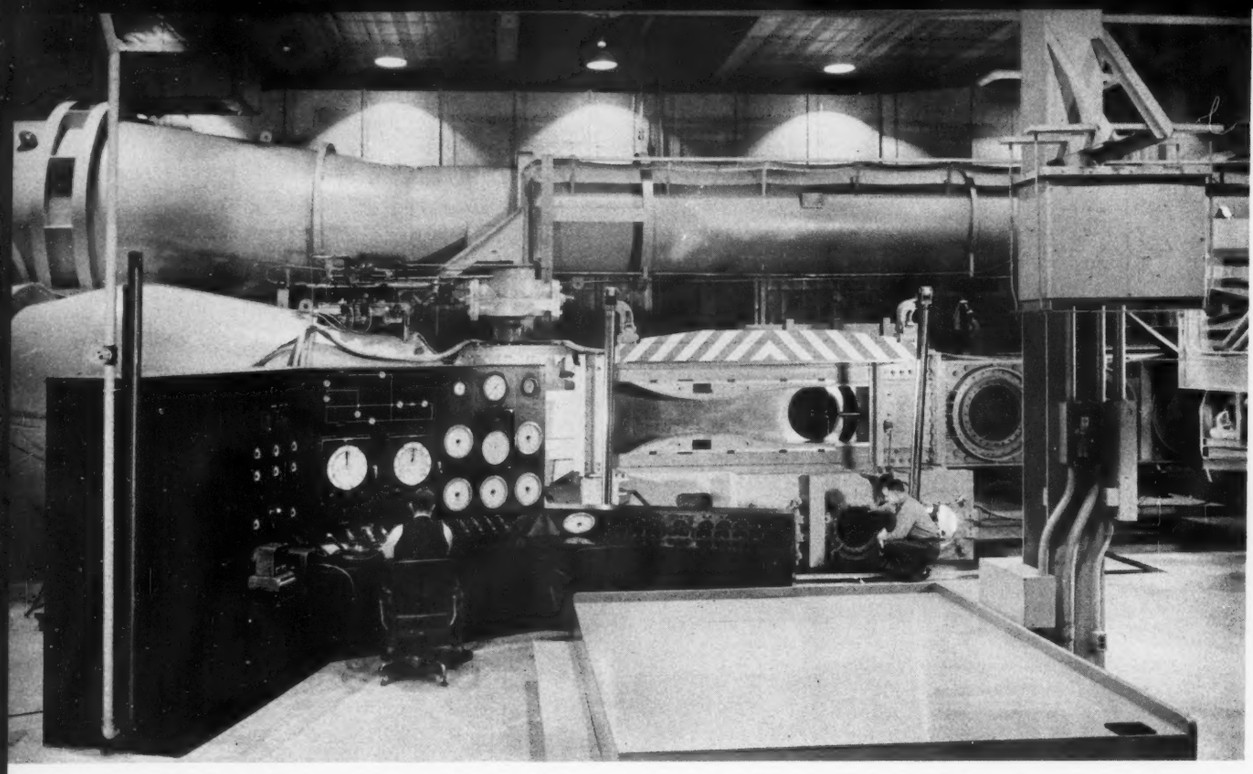
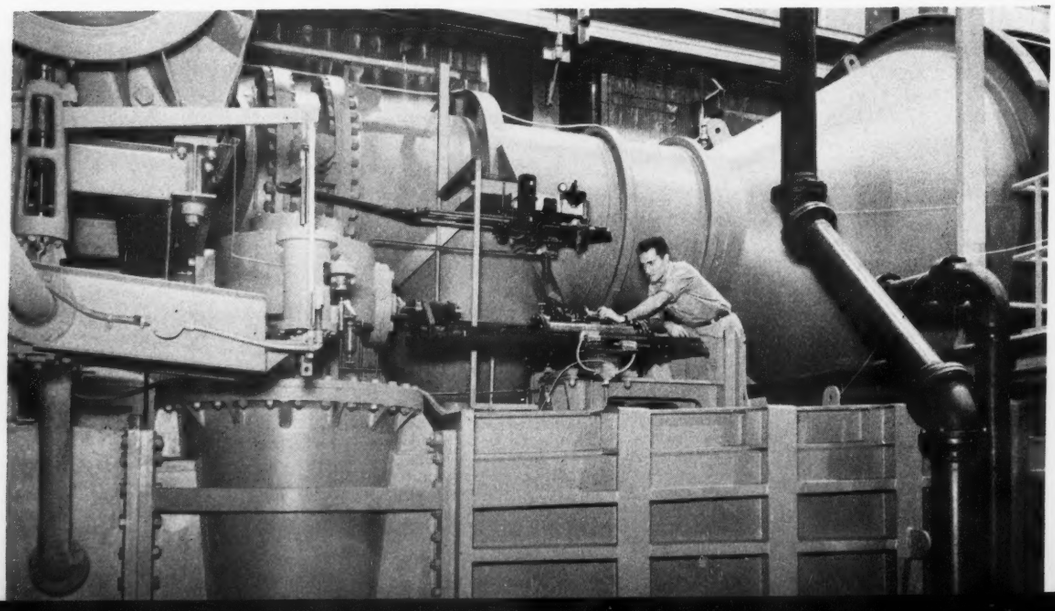
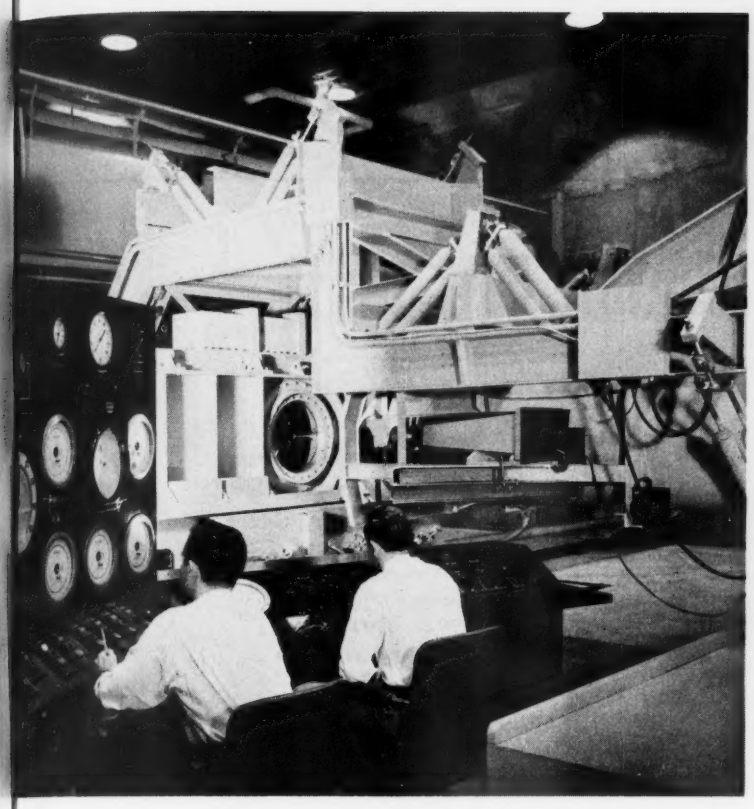


Observations of models in the high speed air stream are made through a circular window in the cover of the test section in the center of this picture.

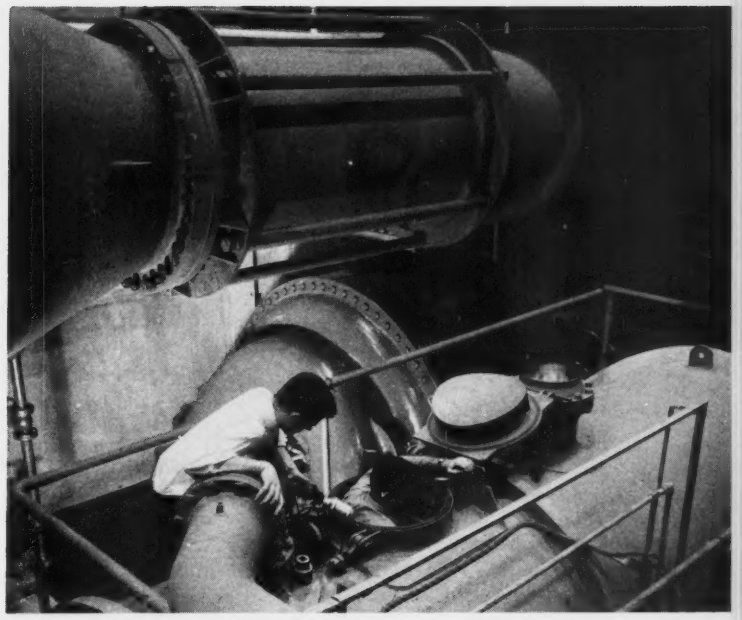
SUPERSONIC

A graduate student operates a valve at the end of the actual test section of M. I. T. 's new wind tunnel at the Institute's new Supersonic Laboratory.





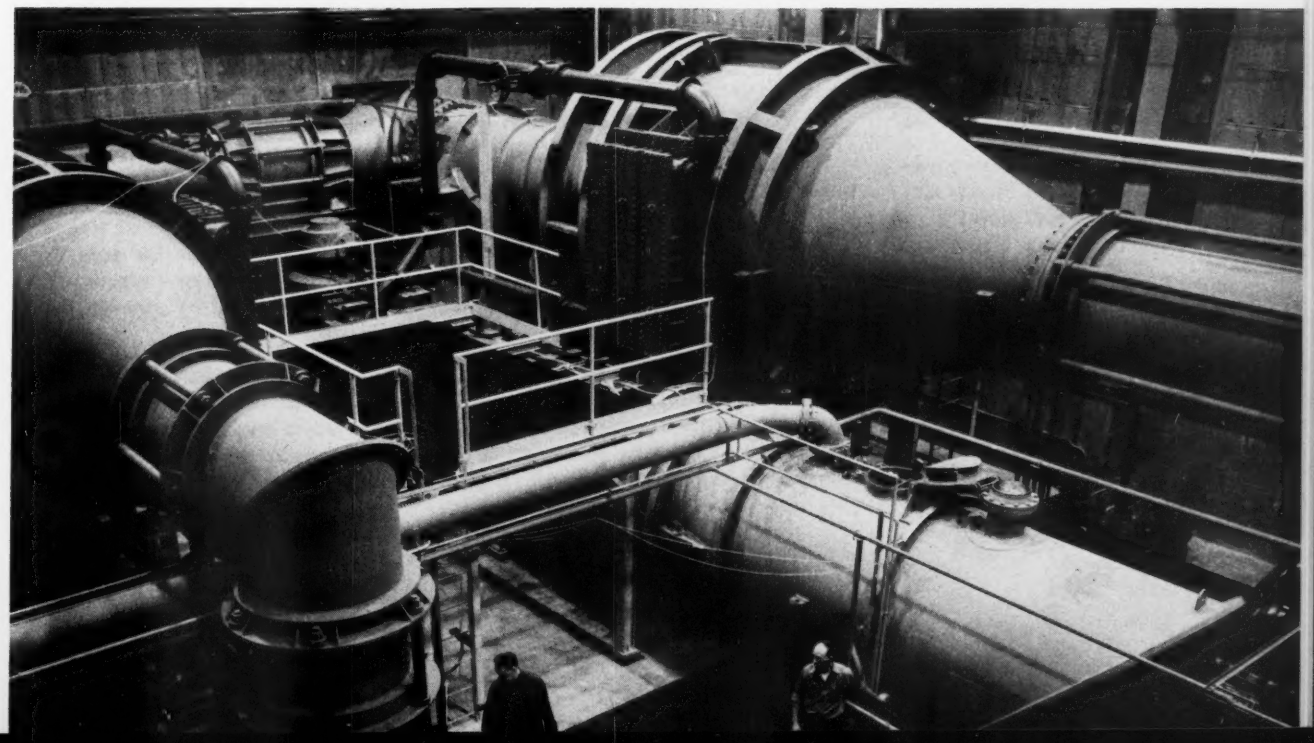
From positions in the foreground, operators control the tunnel. The equipment in front of them is mounted independently of the wind tunnel itself.



After its acceleration to supersonic speed, air from the wind tunnel returns through this duct to be reaccelerated by the compressor in the background.

WIND TUNNEL

The compressors in the foreground, driven by large electric motors, force air through the coolers at the top of the picture.



tech engineering news

Professional Journal of the Undergraduates of the
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from the editor's notebook

Poll . . .

The results of the student living habits poll which have been published in this issue, can lead to only one startling conclusion. It has gradually dawned upon those who worked with the poll sheets that there is nothing surprising in them at all. There are the extreme cases, of course, but on the whole, a Tech student has turned out to be what the Institute's Catalog says he is — does the work stated in the catalog in the time allotted by the catalog, and behaves in every other respect like a normal human being. It is possible that the data given only appear normal to those who are used to it, but we have not lost contact with the outer world so much (the poll says very little) that we do not see how others live. It seems that we live just as they do.

This, naturally, poses a very dangerous situation. Just imagine what would happen to M. I. T.'s standing if it were discovered that everyone in it behaved like a normal human being — think of the loss of face! Possibly the only advantage to the students of M. I. T. in the publication of these results is that any women they may be interested in will stop thinking of them as "engineers" and treat them as normal college beings.

Seriously though, to our eyes, the most interesting fact turned up was the agreement of the catalog with the average student estimate for hours of school work per week. With this agreement should come the answer to a long standing gripe. Everyone is getting what he had been led to expect.

K. K.

More Poll . . .

Are you an average raiser, B.T.O., athlete and social wheel, all rolled into one? Do you play squash, hockey, softball and water polo, not at all to the detriment of your 4.93 cume? Do you work a 48-hour week in a hash house, and spend substantially the rest of the week shaving, donut-dunking, sailing, sculpting, and secretary ogling? Do you paint pictures and write poetry for the *Atlantic* to earn your way through? Do you sprint to classes for the exercise, and confess to your instructor when he awards you undeserved points? No? Honest? Then let's face it, brother, you are shamefully average. You are the man whose life-doings are recorded ($\pm$ 20%) on the preceding pages of this issue. You are an Average Tech Man! Pretty discouraging, isn't it. Don't give up — read the poll results. You may find that you have a few distinguishing characteristics.

By the way, some people who really are far from average apparently do attend Tech. They are, of course, buried under a mass of normalcy as far as our results go. We would like to dig out some of these fellows, but it's hard to separate their statistics from those of jokers who claim 3.14159 ratings, two wives, and 3¼ activities.

The whole thing was more work than we expected. There were some wee hours spent and last minute disappointments endured. From working with the returned sheets we learned a few things: samples of twenty are easy to average but low on accuracy, the human mind is a poor adding machine, and returns of, say, sixty per cent don't guarantee one per cent accuracy in results. We also learned that everyone pitches in cheerfully when there is a little dogwork to be done.

Our sincerest thanks to Dean Burchard, Professor Rule, Professor Jackson and Professor Lineham for their assistance in permitting us to use the courses under their supervision; to the faculty members who took the time to distribute the poll; to the men who filled out the sheets properly; to some of the jokers whose remarks caused some office-wide levity; and to the girls, parents, relatives, roommates and typewriting monkeys who were pressed into service. Our appreciation also to Professor Bavelas for his advice on the make-up of the questionnaires.

G. B. F.

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BALL AND ROLLER BEARINGS

traveling-wave tubes

(*Continued from page 13*)

shows that they make the wave go faster than the electrons. In this case our picture should have been one in which the electrons move to the left with respect to the wave. If we again assume that the electrons move faster than the wave, and also assume that the wave decreases, we find that the electrons are bunched on the down slopes so as to absorb energy from the wave, and give rise to an attenuated wave. Our simple explanation conforms to the picture of three possible forward waves, one increasing, one unattenuated, and one attenuated, which a more trustworthy analysis indicates.

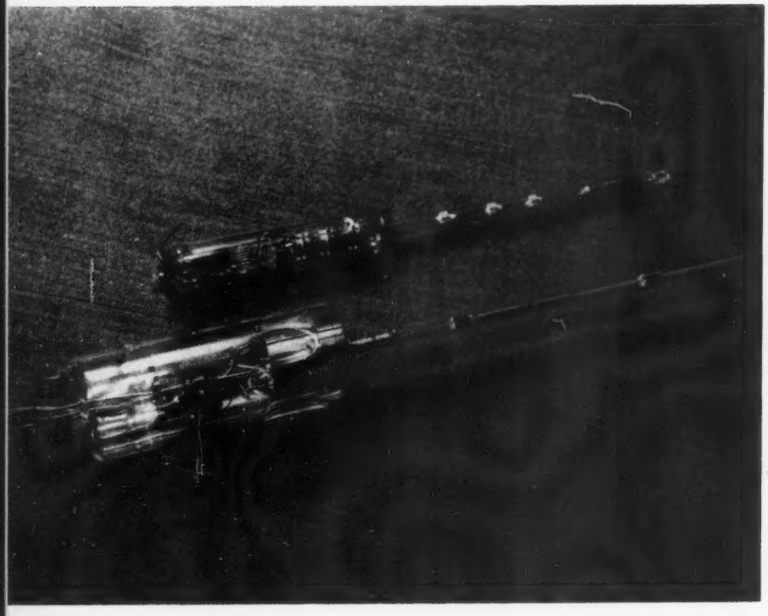
To approach the problem slightly differently, consider the wave traveling down the helix; it consists of an irregular field having peaks and "valleys" of intensity. These peaks constitute a repulsive force to the electrons so that when they approach one of these peaks they are slowed down, producing a bunching effect; as they leave the peak they are repulsed so that they speed up again. When the electrons bunch at these peaks, they act upon the field so as to increase the intensity of these peaks which in turn repulses and slows down the following electrons to a greater extent than the preceding ones, thereby producing even a greater bunching effect. It can be seen that the intensity of each peak is continually increasing as it moves down the helix, and that the bunching of the electrons is correspondingly becoming more and more pronounced. Because of the bunching action, there will be, in time, more electrons decelerated than those accelerated over any cross section of the helix. As a result, there will be a net transfer of energy from the electron beam to the wave.

It is found that as the frequency of the wave is increased, the wave tends to cling close to the helix, and the electric intensity near the axis, where the electrons are, falls off. For this reason, we expect the gain to fall off when the frequency is increased sufficiently. On the other hand, the gain is in the form of a negative attenuation of so many decibels per wavelength. At very low frequencies the helix will be only a few wavelengths long and so we expect the gain to be low at sufficiently low frequencies. It therefore can be assumed that these contrasting effects partially counterbalance each other producing wide-band characteristics or a nearly equal response over a large frequency range. It also enables us to arrive at some general ideas concerning the behavior of traveling-wave tubes. We are willing at once to believe that, for a given energy traveling down the circuit, the stronger the field that acts on the electrons, the more the bunching, the more energy the bunches give up, and the greater the gain.

While traveling-wave tubes were found to have great advantages over other types of tubes at ultra-high frequencies, it was also found that they had certain undesirable drawbacks. One of these was the tendency of many traveling-wave tubes to oscillate. These oscillations were observed to occur at roughly one-half to one-third of the nominal operating frequency of the tubes and at beam voltages which gave optimum gain in the design band.

Work was undertaken on the traveling-wave tube at the Massachusetts Institute of Technology in the Research Laboratory of Electronics by Professor Chu, and a subsequent paper by Chu and Jackson put the theoretical analyses of these tubes on a sounder basis than it had ever been on before. Experimental work by L. D. Smullin and his associates was also carried on and was directed towards developing tubes that would work well at about ninety-five hundred megacycles. One of the results of this study was a better

(*Continued on page 24*)



It is possible to notice the helices which form an integral part of a traveling-wave tube and their supports in this photograph.

New RCA electron tube gives today's amazing computing machines an indispensable memory.

Tube with a memory *keeps answers on file*

So complex are present scientific studies—such as in atomic research—that working out the "arithmetic" could take all of our scientists' time.

Short cut through this drudgery is found in huge electronic computers, able to add or multiply numbers as large as a thousand billion in *millionths of a second.* But such speed is valueless unless—with comparable speed—the results of countless computations can be kept "on file" and taken out again.

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The Shoreland tunnel is 45 ft. long, the other 60 ft.; each is equipped with both push trucks and a conveyor belt, and will handle ANY foods.

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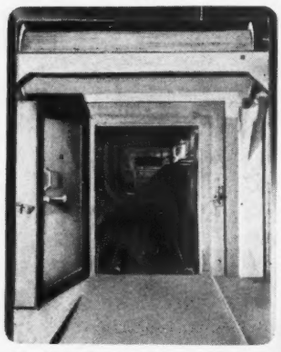

The Sixty Foot Tunnel at the Draper Canning Co. Conveyor Belt is Above Push Trucks

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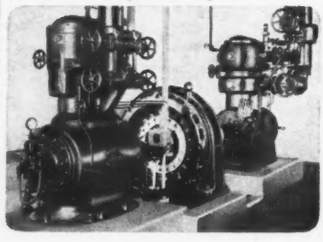

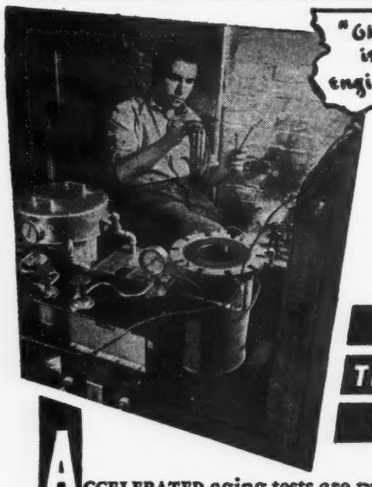

A BOMB THAT DESTROYS GUESSWORK

ACCELERATED aging tests are part of the Okonite product improvement program. While they cannot replace the study of actual exposure to weather in proving ground and in the field, they have a definite place in estimating the value of electrical insulation.

The oxygen bomb shown at the left is used in accelerated aging tests — one piece of apparatus among many other examples of modern equipment at the service of Okonite engineers and technicians in taking the guesswork out of the manufacture of insulated wires and cables. The Okonite Company, Passaic, New Jersey.

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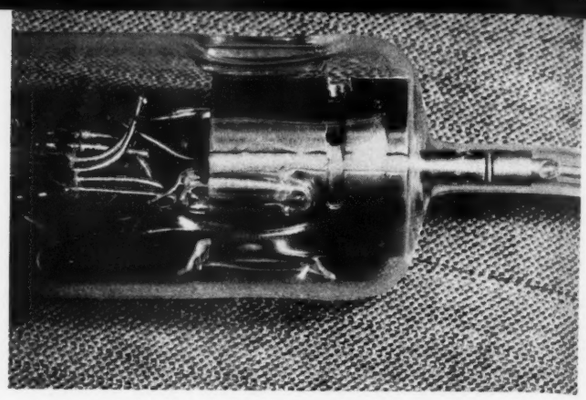
insulated wires and cables



This closeup of a traveling-wave tube showing the gun assembly.

traveling-wave tubes

(*Continued from page 22*)

understanding of the causes of oscillations in traveling-wave tubes.

Analysis indicated that gain is obtained only when the electron velocity is within about one per cent of the wave velocity. Analysis also indicated, however, that when the two velocities were equal in the pass band, they would be far from equal at the lower frequencies where oscillations actually occurred. Since gain is a requirement of oscillation, the tube constructed obviously did not correspond exactly to the theoretical tube. The results of some of the experimentation done at M. I. T. helps to resolve this discrepancy.

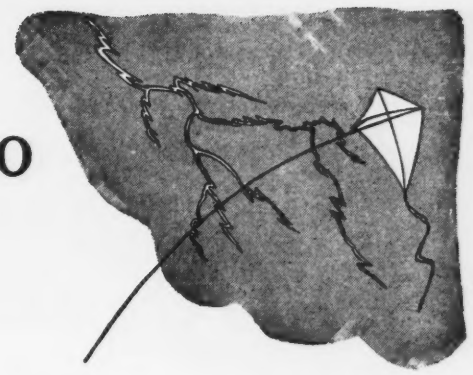
There are a number of ways of supporting the helix within a traveling-wave tube, one of the most common methods being by four dielectric rods placed symmetrically around the helix and lying parallel to its axis. When the measured phase velocity along a helix thus supported is plotted on a graph as a function of frequency, a marked dip is noticed in the velocity characteristic. In fact, the beam velocities required for gain are the same at $2\pi a/\lambda = 0.25$ and 0.12. This could well explain the observed low-frequency oscillations. On a basis of this and other data, certain electrical criteria were formed which should be satisfied by the mechanical construction of a traveling-wave tube.

First, insofar as possible, the helix diameter should be proportioned to make the gain a maximum within the pass band. For velocities of about one tenth the speed of light, the ratio $2\pi a/\lambda$ should be about 0.1. Second, the dielectric supporting structure should be arranged so as to maintain the dispersive character of the helix. This will reduce the electronic gain at frequencies outside the pass band of the tube and thereby decrease the tendency toward oscillation.

The heart of the traveling-wave tube is the electron gun in which the electrons emitted from a hot cathode are first accelerated to give them considerable velocity, then formed into a beam, and finally allowed to strike an anode situated at the far end of the tube. The gun assembly can be seen in the photographs through the glass at the large end of the tube. There is a gun anode placed near the cathode which is operated at a high positive potential in respect to the cathode, thus accelerating the electrons that are emitted, and which is provided with small apertures through which the electron stream passes. On emerging from the apertures the electrons are traveling in practically parallel straight-line paths. As the electron beam travels down the narrow end of the tube through the helix, there is a tendency for it to disperse with a resulting loss in beam current. This is especially true since the helix is made

(*Continued on page 26*)

What was the key to Ben Franklin's success?



It wasn't the one on the end of this kite string, you can be sure. The key to Franklin's basic contributions to the progress of science and engineering in America was his solid grounding in technical fundamentals. In America, the finest textbooks are available to everyone. They provide the indispensable background in technology that has made and keeps America great.

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traveling-wave tubes

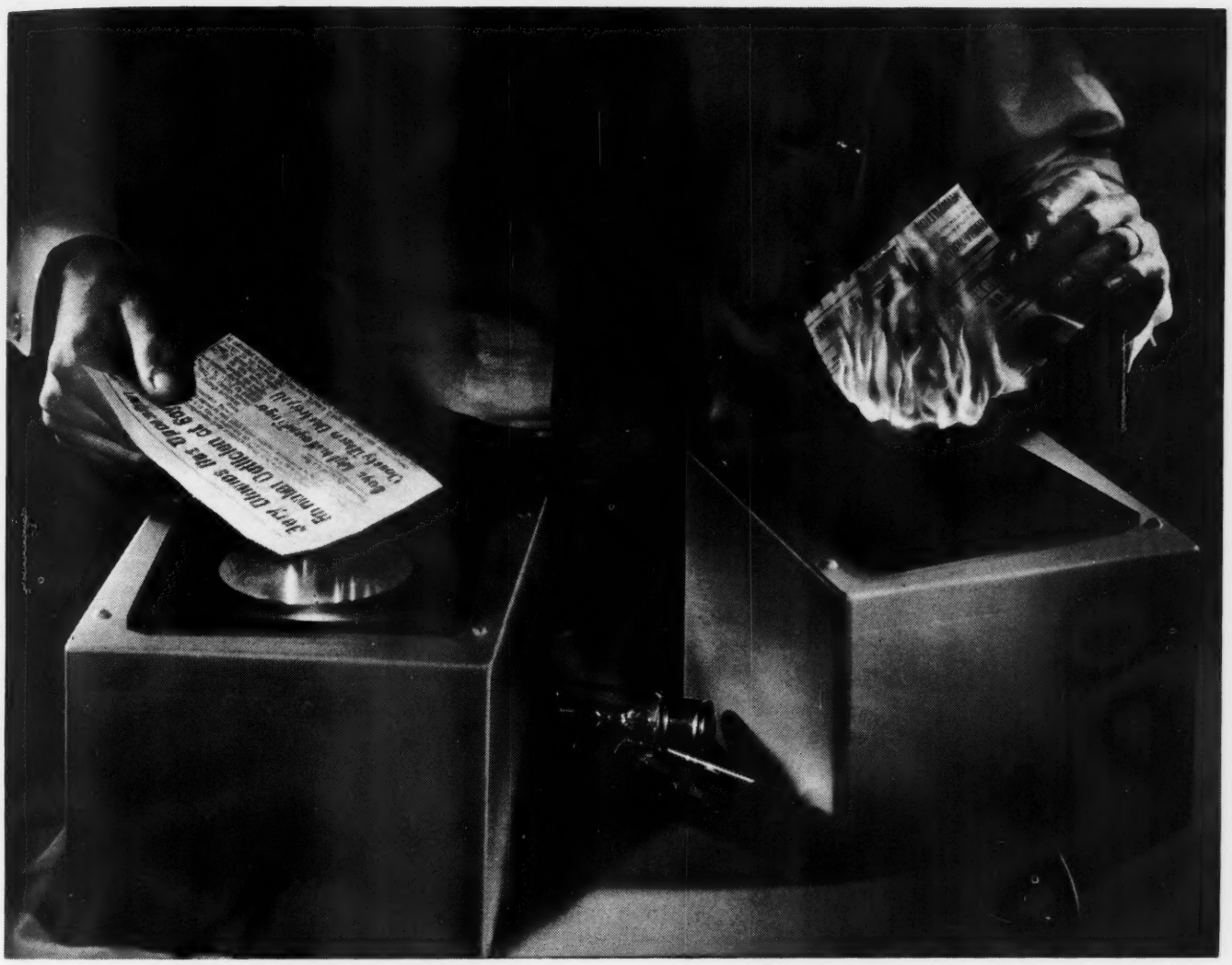
(*Continued from page 24*)

very long with a small inside diameter. This problem has been effectively solved by placing around the helix and outside the tube a magnetic coil through which direct current flows. The resulting magnetic field tends to focus the electrons into a narrow beam along the entire length of the helix. In one of the photographs, this coil can be seen surrounding the narrow end of the tube.

The following operating conditions and performance are typical for a tube such as those shown in the photographs:

Beam voltage	1670 volts
Cathode current	8 milliamperes
Collector current	6 milliamperes
Gain at 3600 megacycles	23 decibels
Bandwidth between 3 decibels	800 megacycles
Power output	200 milliwatts
Transmission loss with beam off	33 decibels

Theoretically, the inherent noise within traveling-wave tubes can be reduced to an extremely low level; as yet, however, this has not been realized in the actual tubes that have been constructed. Higher power than has previously been attainable is another goal towards which research is being directed. Traveling-wave tubes have a promising future as irreplaceable tool in ultra-high frequency applications. Their extremely wide-band characteristics make them particularly applicable for communications, but it is probable, too, that after further research and development, they can be applied to many other uses as well.



Glass that picks fire out of a light beam

The electric lamps you see between the boxes on the table are exactly alike—they generate both powerful light *and* intense heat.

If you should concentrate the beam of one of them with a reflector and plug it into an ordinary socket, you'd be practically blinded by its glare and your clothes scorched by the heat—unless you turned away fast!

But look what happens when you put them into the fixtures in the foreground, so their beams are covered by two different kinds of Corning glass.

The beam from the bulb on the left is cooled down so sharply that you can hold a wisp of newspaper in it for hours without its catching fire. Yet the light is almost as dazzling as ever.

Notice now that no light apparently shines from the bulb in the fixture on the right. But if you hold a piece of newspaper over it—in a matter of seconds you have fire in your hands!

The explanation is: One of the glass plates transmits the comparatively cool, visible rays generated by the bulb, blocking off most of the invisible heat rays. The other allows only the invisible heat rays to pass.

These pieces of glass are only two of the dozens of ray-transmitting or ray-blocking glasses that Corning makes—glasses that can pick out any segment of the light spectrum and put it where it's needed.

For example, a lamp shielded with a Corning glass which transmits *only* near ultraviolet rays lights automobile instrument panels without glare. Another kind of Corning glass transmits only invisible infrared rays and is used in electronically controlled burglar alarm systems.

Throughout industry, *Corning means research in glass*—and these ray-blocking, ray-transmitting glasses represent only one of a multitude of outstanding developments that have earned Corning this reputation.

We hope you'll keep in mind that Corning research and technical skill have made glass one of the most versatile engineering materials there is.

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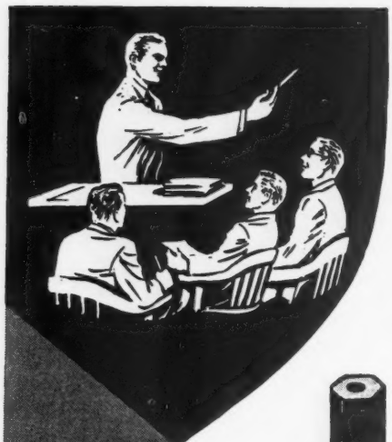

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reality (*Continued from page 15*)

"Did you notice the star patterns in that vicinity?" asked Bench grimly. "No. What about the star pattern?"

"There isn't any!"

"What?"

"I said there isn't any. Check me . . . open your lateral visors and look." Joe got up and left the room. I remained there . . . I didn't want to go back through the bank rooms. I continued to stare into the visor. Bench was sitting before his transmitter hunched over and had his elbows leaning on the small ledge before the screen. I saw Jimmy come in through the door behind him. Bench must have heard him, and he turned around to stare at Jimmy.

"How do you feel, kid?"

Jimmy nodded weakly, saw me in the screen, and crossed the room to greet me.

"Hello, Rudy . . . How are you?" He was pale and looked as though he had lost twenty pounds of his already puny frame.

"Okay, Jimmy. . . . You're not alone in this madness . . . as a matter of fact, about everybody has experienced this thing already, and now it's our turn."

"There aren't any more stars in the Basin," he said simply.

"Then you see, I was right," added Bench expressionlessly.—"Yes."

"The blot is expanding, isn't it?"—"Yes."

"Do you want to know what I think it is?" Bench said this through clinched teeth . . . "Jimmy gave me part of the idea yesterday afternoon, before he went into our number five." Bench paused. He looked at Jimmy beside him . . . the kid was staring into space and apparently he hadn't even heard Bench voice the question.

"You know," Bench started, "it all sounds or seems incredible that something like this could happen. It is a pure contradiction to all we have maintained as impossible. We have the system of the world . . . the universe . . . all figured out right down to any decimal place you care to have one of the computer banks work out. . . . "

"We were discussing that together just this very morning," interrupted Joe.

" . . . and," continued Bench, seemingly unaware of Joe's interruption, "all events were predictable from our mathematics. This should have been foreseen, and certainly could have been averted. But we didn't foresee it. Witness the black expanding blot out there. The entire system is falling in like a house of cards. . . . We looked too close, Joe . . . we looked too close." He paused and watched our faces. Joe's was a white blank, and I felt sick. I was just beginning to get what he meant . . . I think . . . something racked me from within when I visualized that concept . . . thought. I was beginning to muddle my thoughts . . . they came sluggishly . . . I seemed to hear Bench continue:

"We looked too close . . . something like being curious about a cloud in the sky. You get tremendously curious. It looks solid from the ground and from a distance . . . but start getting really up close to it and look around. There is not very much there. Am I getting across to you what I am driving at?" asked Bench.

"You're getting it across only too well, Bench," I managed to say.

The image on the screen began to swim . . . I heard Jimmy and Bench start to scuffle in their communications room . . . something like two cut-off screams came through the speaker a split second before the screen blinked.

Joe started out of his abstraction and flipped on non-receiver communication and played the probes over the vicinity of SO-A/C-10997 . . . nothing showed. There seemed to be a tremendous draw on the power as he swept the prober over the vicinity. He shut it off. "There is no more station out there," he said.

He turned to face me as he said the last sentence. . . . I couldn't look at him . . . his nose wasn't where it should have been . . . I stifled a cry, and ran out of the room. The corridor twisted and I felt a wave of nausea sweep over me. I lurched through the corridor . . . the walls were folding in; they seemed to press close to me as I dashed along the hall. I could hear Joe's heavy breathing behind me . . . he was muttering and talking things I couldn't understand. I cleared the corridor and entered the bank room at a full run . . . I don't know how I ever kept my balance on that curving, twisting floor. The machines were shrieking and screaming and

(*Continued on page 30*)

THE DU PONT DIGEST

FOR STUDENTS OF SCIENCE AND ENGINEERING

BAD MEDICINE *for flies*

Research that produced an insecticide safe to spray on cows may save millions for American agriculture

Armed with only a fly-swatter, the farmer would get nowhere in ridding his dairy barn of disease-carrying insect pests. But he has to be careful in using insecticides around cows. A toxic spray may be absorbed through the animal's skin and show up in meat, milk and butter.

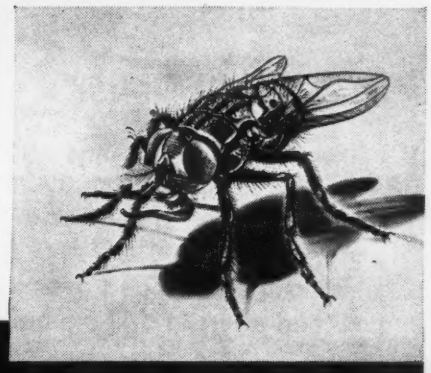
Next fly-season farmers and ranchers will be able to buy a fly-killer that is both powerful and safe. In Du Pont Marlate* 50% technical methoxychlor insecticide they will get this combination of properties that no single insecticide has ever offered before.

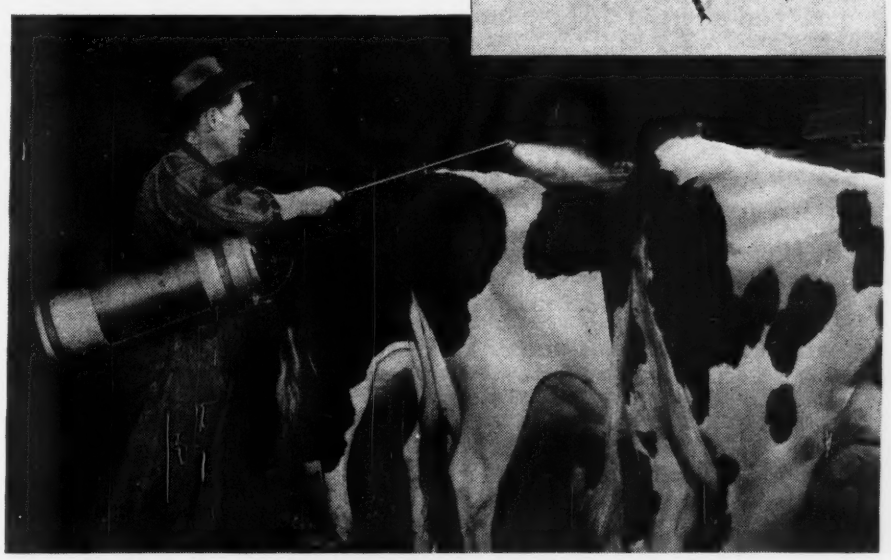
Methoxychlor is a recent Du Pont development. Du Pont scientists worked for eight years in the laboratory and in the field to develop its applications in agriculture.

A safer insecticide

"Marlate" 50 is a residual insecticide and remains an effective killer of flies, mosquitoes, fleas and lice for several weeks after application. When used as directed, this insecticide is exceptionally safe to human beings, livestock, pets and crops. This has led federal experts to recommend it not only for spraying in barns, milk houses and milk plants, but also on the animals themselves.

Besides its use on livestock, methoxychlor kills many insects that attack vegetables, fruits and forage crops. It is offered to flower growers as an ingredient in Du Pont Floral Dust. It is used in moth-proofing compounds so that dry cleaners can easily moth-proof woolens while cleaning them. Many stores carry aerosol bombs containing methoxychlor for household use. It can be used with safety in flour mills, freezing and canning plants, grain storage elevators, cereal manufacturing plants—wherever food is processed. This development of research can bring immediate cash savings of millions of dollars to American agriculture, industry and homes.





THE BITES *of flies, lice, and ticks can cut down milk production as much as 20 per cent. One spraying of "Marlate" 50 will control these pests for several weeks.*

The long fight

Exciting as the future of "Marlate" 50 appears, this does not mean that the use of other insecticides will not continue. Each has its special characteristics, and each has special uses for which it is outstanding. There are at least 10,000 kinds of insect pests, of more or less importance, in North America, and there can be no let-up in the scientific fight being waged against them.

Du Pont alone now makes over fifty different insecticides. The knowledge gained in making each one speeds the development of the next. By backing ideas with funds and facilities, Du Pont helps the farmer put more and better food on the American table. At the same time, in many other fields, Du Pont is helping to raise the American standard of living with continuous research aimed at developing new products and improving present ones.

*REG. U. S. PAT. OFF.

***"MARLATE"** 50 kills flies and many other insects attacking livestock, vegetables, fruits and forage crops.*

SEND FOR "Chemistry and the Farmer," an interesting, informative booklet on the development of pest control, etc. 34 pages. For your free copy, write to the Du Pont Company, 2503 Nemours Building, Wilmington, Del.

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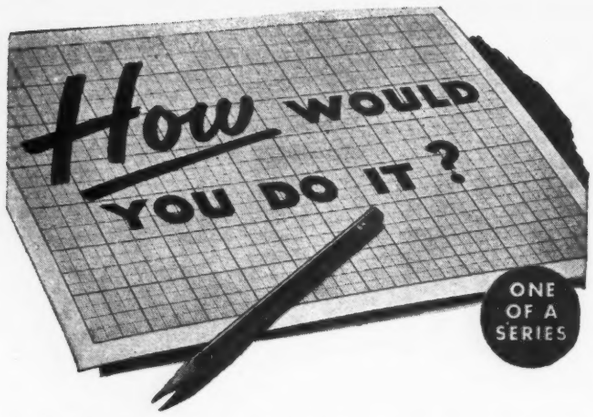


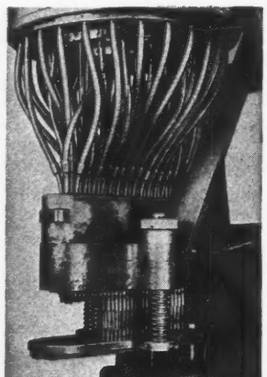
PROBLEM — Your company manufactures gas burners of varying number and spacing of gas ports. You want to develop a drilling machine which can be changed over with a minimum of time and effort to drill the holes in the different burner castings. How would you do it?

THE SIMPLE ANSWER—The illustration shows how one manufacturer solved this problem by using S.S.White flexible shafts as spindles. This arrangement makes possible quick changes of spindle groupings to meet different requirements. As here, S.S.White flexible shafts make ideal power drives for almost any machine part which must be adjustable.

★ ★ ★

This is just one of the hundreds of remote control and power drive problems to which S. S. White flexible shafts provide a simple answer. Engineers will find it worthwhile to be familiar with the range and scope of these *"Metal Muscles"** for mechanical bodies.

* Trade Mark Reg. U. S. Pat. Off. and elsewhere.



WRITE FOR BULLETIN 4501

It gives essential facts and engineering data about flexible shafts and their application. Write for your free copy.

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BROWN & SHARPE B·S

reality

(*Continued from page 28*)

they were moving about in the room. They were moving through each other, and through . . . out through the walls. Several of them got into my way, but before I could change my course on the terribly twisting floor, I found that I had passed clear through them. I entered control and threw myself on the central panel, I was tearing furiously at the snaking cables with my bare hands. . . . I smashed the plastic dials and kicked in all the buttons and bent the switches. I cut off all power condensors that were sucking energy from the outside . . . from non-existent stars. I felt Joe beside me . . . he was kicking and tearing at the central power distributor that fed non-existent energy into non-existent computers that were working out with great detail non-existent problems.

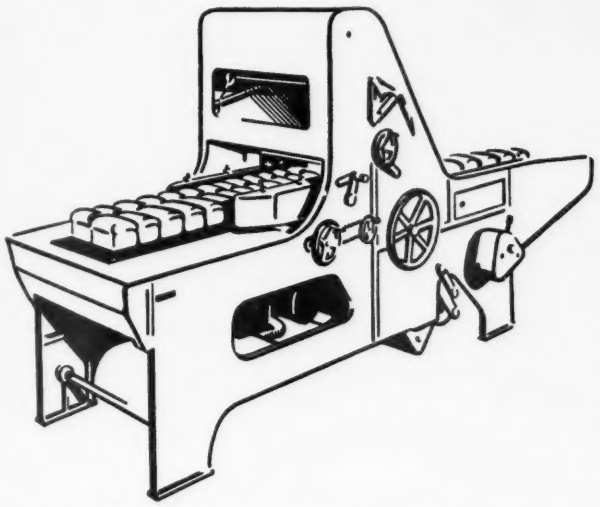
"God . . . who would have . . . who could have thought of it?" I heard him scream above the wail of the cracking computors. " . . . forcing existence. . . . " I heard him shout. He started to laugh. . . . The laugh got louder and more shrill. . . . It degenerated into a scream.

I looked at Joe aghast . . . he had fallen to the "floor" and was crawling around pulling a chest and torso around . . . he had nothing from the hips down.

" . . . forcing existe . . . "

I heard Joe's screams die away with the rest of the sound outside . . . the panel grew transparent and I saw empty space through the dissolving walls of the non-existent shell. I couldn't help it . . . but I had to think about it . . . but the more I thought, the more nebulous the scene about me became. . . . Wavering shocking waves of last, and final nausea . . . unreal nausea coursed through a body that didn't exist and shouldn't have experienced it. I thought and tried to rationalize the phenomena. . . . I thought, and the last vestige of reality slipped into nothingness.

Another page for **YOUR BEARING NOTEBOOK**



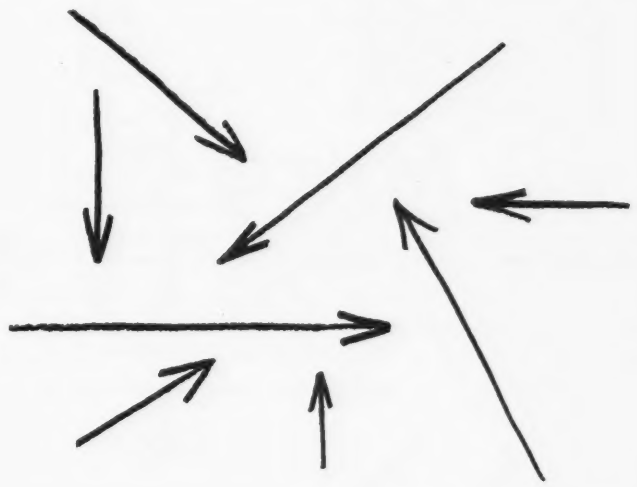
How to help a bread slicer carve a name for itself

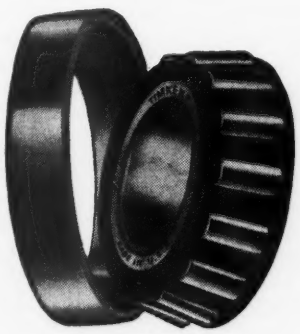
Designers of a new, 75-loaves-a-minute bread slicer were looking for a way to insure long-term accuracy and minimum maintenance. They found the answer in Timken® tapered roller bearings.

Timken bearings keep the knife drum shafts in rigid alignment, maintain precision movement of parts. They require minimum attention, normally last the life of the machine. And they permit tighter closures that keep the lubricant on the bearings . . . off the bread.

Why they all look alike to a TIMKEN® bearing

Loads from any direction—radial, thrust or combinations of both—are carried by Timken bearings, thanks to their tapered design. Timken tapered roller bearings make auxiliary thrust bearings and thrust plates unnecessary . . . simplify design, save space, cut costs.





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TAPERED ROLLER BEARINGS

Want to learn more about bearings?

Some of the important engineering problems you'll face after graduation will involve bearing applications. If you'd like to learn more about this phase of engineering, we'll be glad to help. For additional information about Timken bearings and how engineers use them, write today to The Timken Roller Bearing Company, Canton 6, Ohio. And don't forget to clip this page for future reference.

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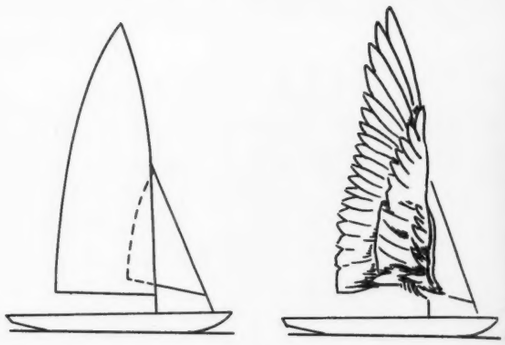


Comparison between the sail and the wing. The sail plan is one similar to many used in European waters, and it follows the contour of the wing very closely.

the science of sails

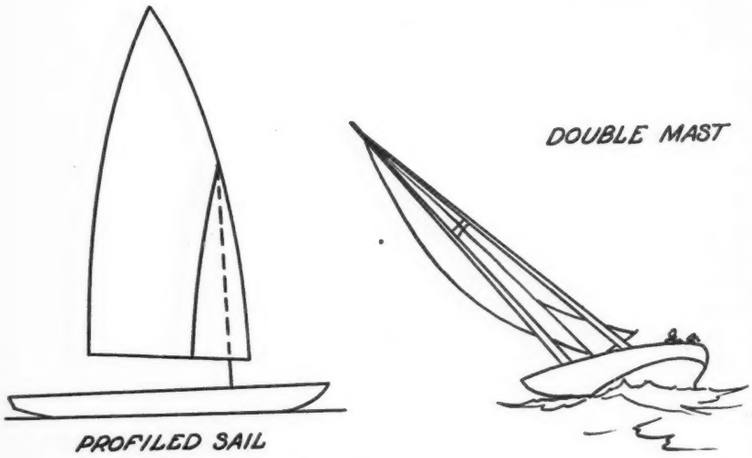
(*Continued from page 17*)

erally speaking, the only advantages of the gaff are that the sail sets better before the wind, and develops more drive with the wind abeam. But the weight of the gaff, the bother of having two halyards, and, on larger craft, more stays, and the relative lack of control which the rig affords the helmsman far outweigh its limited advantages.

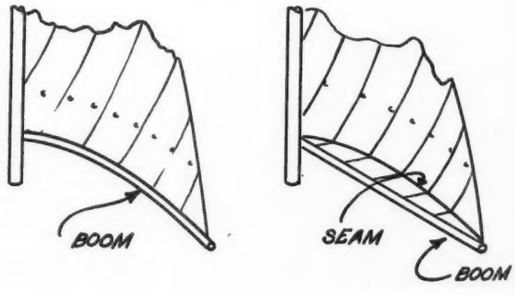
A great deal more could be written about the arching of the sail without getting much of anywhere. The value of perfect curvature in the sails of a cruising yacht does not offset the trouble and expense of assuring it. But in modern racing sailboats, where every bit of speed is needed, it is only sensible to use every trick possible to win those races.

There has been, in the past half century, an immense amount of experimentation with various mast designs. The reason for this is apparent when we realize that the driving force of the mainsail is reduced twenty to forty per cent through the presence of the ordinary mast. The mast, by breaking the air currents before they pass along the sail, causes eddies, or turbulence of the wind along both sides of the sail. The force required to form these eddies would ordinarily be imparted to the sail. To combat this loss, a number of devices have been tried, most of which have improved the driving force of the sail. The first, and perhaps the most common trick has been to close the gap between the sail and the

(*Continued on page 34*)



The profiled and the double mast — two ways by which the efficiency of the sail may be increased.



Two ways of permitting the foot of the sail to arch. The boom may be flexible, or an additional piece of cloth inserted at right angles to the sail. The seam has a batten inserted in it to maintain the shape.

Thinking of improving

"Improving" any machine really means increasing its productive capacity. That means tinkering with speeds and weights and strength—ending up with alloy steels.

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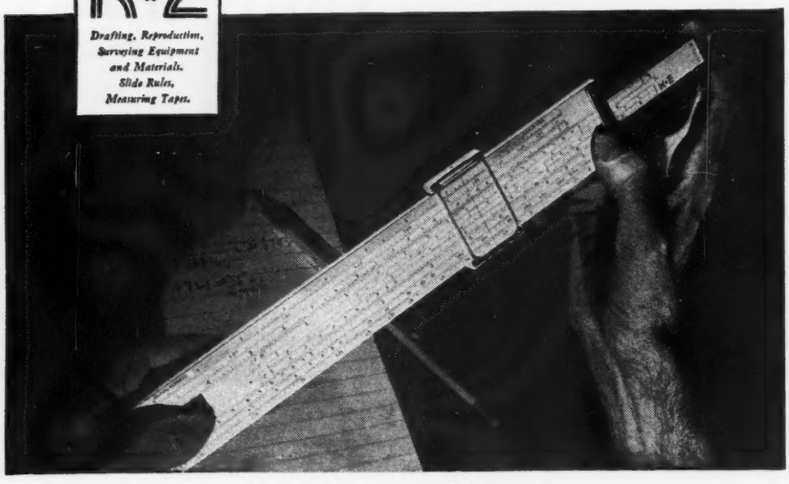

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the science of sails

(*Continued from page 32*)

mast, caused by the use of sail track or lacing, by putting a slot in the after part of the mast into which the sail fits snugly. Tests have shown this to increase the pressure on the sail by about fifteen per cent. Then the mast may be streamlined, for, giving it the shape of an airfoil may improve the pressure by as much as forty per cent over the round or rectangular mast. Some experiments have been made with setting the streamlined mast by a ball and socket joint, allowing it to turn with the sail, although except in extreme cases the trouble in fixing stays to a pivoted mast is hardly worth the added advantages.

More extreme is the profiled sail, an airfoil shaped covering constructed over the mast and luff of the sail, and extended well aft. This forms a type of envelope which revolves about the mast. Still more radical is the double mast. Two light spars are fixed to the deck, one on either side, and these are connected at the top. A thin cable is stretched between the deck and the top of the spars; on this cable the sail is bent. Besides allowing the air currents to pass unhindered over the surface of the sail, this has the added advantage of replacing the side stays. The increase in weight is not great, since each of the two spars may be much lighter than the single mast. This is perhaps the best method — on paper at least — of avoiding turbulence about the mainsail. In effect, it merely allows the main to be set in the same manner as a headsail.

Now how about the material out of which the sail is to be made? From the study of the bird's wing, once more, we find that nature places a strong emphasis on the smoothness of the surface, and from careful experimentation, we find that if the surface of the sailcloth is smooth, the friction of the air passing over it is decreased, and the driving force of the sail increased proportionately. In the case of duck, the chief difference between fine and coarse material pertains to the number of tiny fibres hanging from it. These tiny fibres, hardly perceptible to the eye, are the major factor causing the retarding friction force. They cannot be eliminated, although they can be made to lie flat on the surface by dampening the cloth, or by coating it with kerosene.

There has been a great deal of talk lately about nylon sails. Thus far, in the relatively short time they have been pulling boats about, they have shown themselves to be a great improvement over duck. Most of the stress has been laid, by those who talk nylon, however, on such things as: nylon is stronger, nylon is lighter, nylon dries better and will not mildew, and nylon won't lose its shape. But little emphasis has been placed on the fact that nylon is a glass smooth material, with none of those efficiency-reducing fibres clinging to it. This should be a strong point in the nylon-duck controversy.

In conclusion, let me point out one other development which has come into wide use in the last century. This is the motor. When all those little improvements on the sail fail to pick up a breath of wind, you can always depend on the motor to get you home — provided, of course, that you remembered gas.

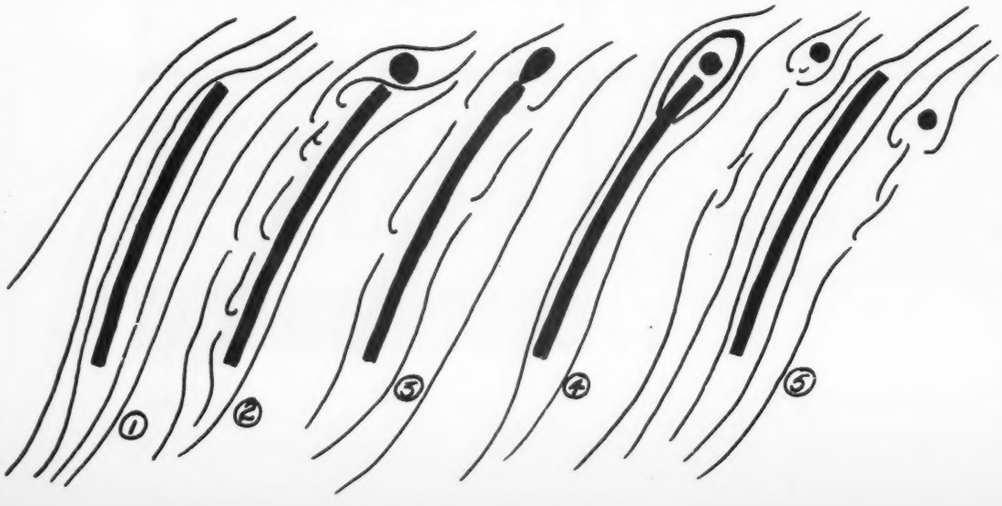
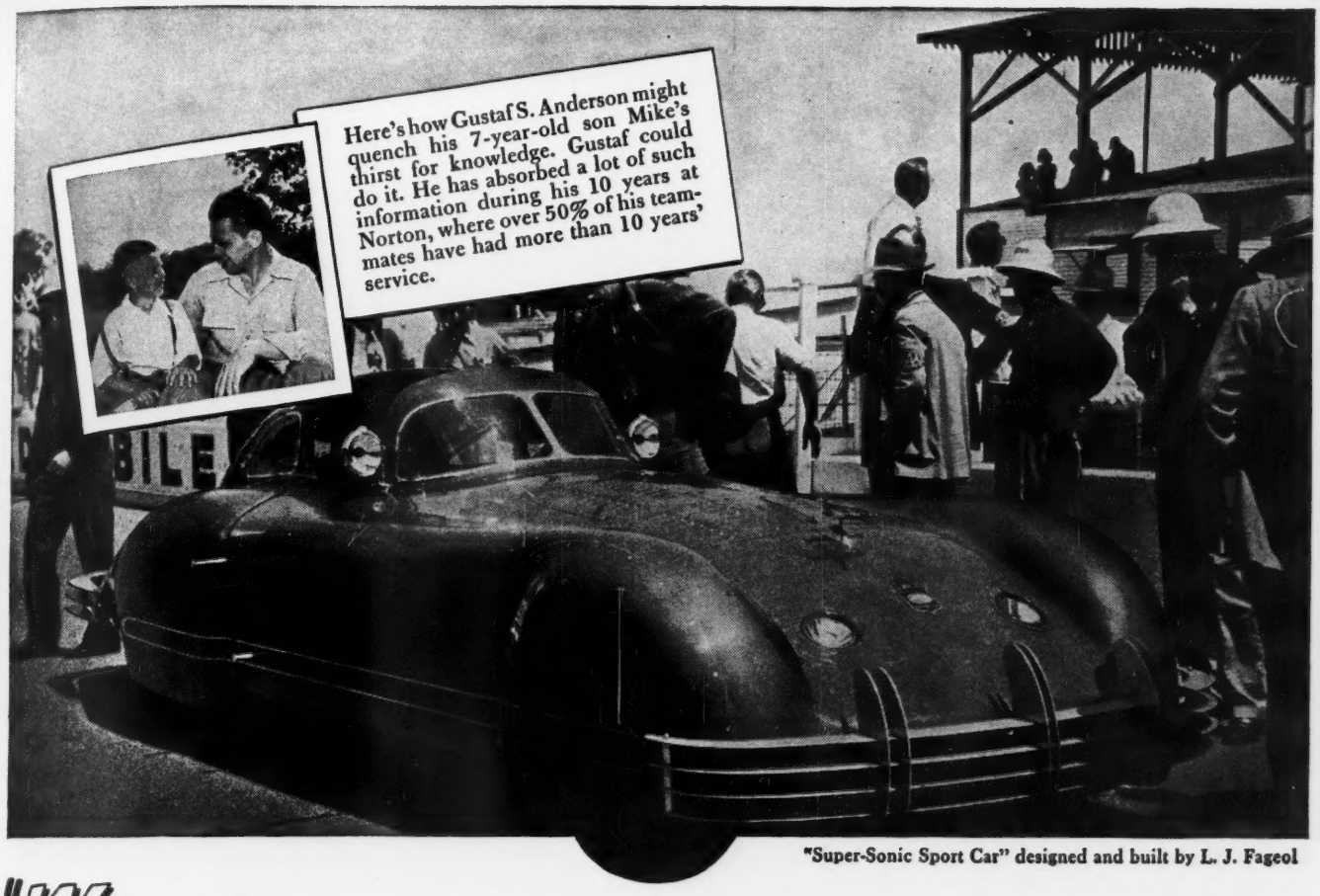


Diagram showing the air flow about various sail arrangements. 1. Sail with no mast — smooth flow, but the thing has to be held up by something. 2. With the ordinary mast the turbulence is very great. 3. With a streamlined mast and the gap between the mast and the sail closed, it is greatly subdued. 4. The profiled sail cuts the turbulence to nearly nothing. 5. The double mast. Negligibel eddies form about the masts, but the flow over the sail is smooth.


Here's how Gustaf S. Anderson might quench his 7-year-old son Mike's thirst for knowledge. Gustaf could do it. He has absorbed a lot of such information during his 10 years at Norton, where over 50% of his team-mates have had more than 10 years' service.

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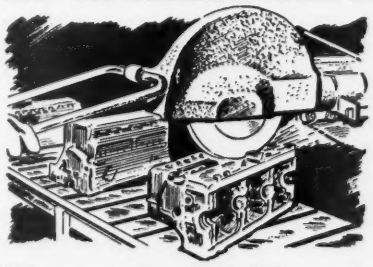
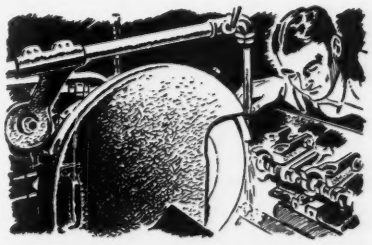


"Norton grinding wheels help — and they start on the first rough castings. Our hones make cylinder walls smooth and long-lasting. Dies and tools are manufactured and maintained with Norton grinding wheels.



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briefing the news

Four-Foot Nose . . .

A new radiation detector with a "nose" four feet long is shaped like a long-barrelled pistol and will provide better protection for atomic researchers. The new instrument is called a "long-probe gamma survey meter."

At the tip of the long probe is an electronic tube which has a phosphor attached to it. This material gives off light in the presence of radioactivity. The light from the phosphor acts upon the electronic tube and is converted into electrical energy. At the other end of the instrument, a meter is activated by amplified current from the tube. This meter measures the amount of radiation exciting the phosphor. The instrument is powered by batteries.

Lighter Light Bulbs . . .

A new interior coating for incandescent light bulbs will provide a greater and more uniform diffusion of light without the prominent bright spot which has characterized the center of the bulb in the past. The new coating is a specially prepared and fortified silica aquasol.

The new coating is made practical by improved adhesion qualities and by greater stability of the coating itself.

De-Icer . . .

A new salt product which will tend to prevent rusting of car fenders and underbodies when used to de-ice streets and highways is now available. It includes a rust-inhibiting chemical which forms a colorless, invisible protective film on metal surfaces. Thus the fenders, which are often corroded when slush splashes against them, will receive an extra measure of protection. The new chemical can be used in place of the salt which has been available in the past.

Sound Quality . . .

Engineers are now beginning to study sounds in terms of their changing quality as well as in terms of loudness and frequency at a given time. It is quite possible that the small variations in quality are responsible for the characteristics of certain sounds that the ear can detect but which instruments have not been able to measure.

There have been, for instance, up to the present time, no instruments capable of distinguishing between a note played on a Stradivarius and the same note played on an ordinary violin.

Cricket noises are another example of sounds that cannot be completely understood in terms of conventional measurements of loudness and frequency alone. Cricket noises coming through a window are not ordinarily loud enough to register on most sound-measurement machines, but there is something about them which has an effect on human ears far out of proportion to their energy which is only about 1×10^{-9} watts.

Ship Energy . . .

The energy expended by a ship on any given voyage can be measured by a new electric instrument which is known as a "marine shaft horsepower-hour meter." The meter indicates both the power being transmitted to the propellers at any instant and the total energy expended over a period of time. The energy measurement is registered in terms of horsepower-hours and is reportedly accurate within two per cent.

The instrument is expected to prove valuable in keeping a continuous check on the performance of ships' power plants, enabling operators to select the most economical speeds for the plants, and indicating when the ships should be dry-docked because of drag caused by fouled hulls.

Element Detector . . .

It is now possible to examine an unknown substance and determine, within a few minutes, what elements are contained in the substance and how the atoms in them are arranged. A new instrument called the "x-ray spectrogoniometer" is responsible for this development. The machine makes its analyses by means of x-rays, a sensitive Geiger counter, and a system of very accurately machined gears.

The sample to be analyzed is mounted in the center of a large table. An x-ray beam is passed through it, and the Geiger counter, moved by precision gears, rotates around it slowly, measuring the intensity of x-rays scattered by the sample at every angle. The intensities of the x-rays and the angles at which they are scattered are automatically recorded in the form of a graph. Since the way in which a substance scatters x-rays is governed by the type of atoms it contains, this procedure gives a direct indication of the elements in the sample. This technique is much faster and more accurate than the older photographic method.

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WIRE ROPE made of "Blue Center" steel has extraordinary ability to withstand abrasion, shock and fatigue—a roundabout way of saying that it lasts longer and costs less! And "Blue Center" steel is an exclusive Roebling development—made only by Roebling. It is a matter of record that Roebling "Blue Center" Steel makes today's unbeatable wire rope for performance and economy.

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PLASTICS—A MULTIMILLION-DOLLAR INDUSTRY AND STILL GROWING

"Plastics" to most people connotes something modern—something new. And the plastics industry, as it now exists, is still an infant, but a lusty and vigorous one.

How fast it has grown in a short span of years is indicated by these figures, which show the number of plastics molding plants in the United States in the last thirty-nine years:

1910	8 plants
1920	63 plants
1930	172 plants
1940	575 plants
1949	1,160 plants (estimated)

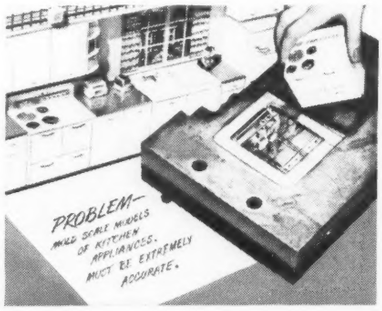
The Ancients Molded Plastics

But the art of casting "plastic" material in molds is an old one. As long ago as King Solomon's time, asphalts and mineral tars were being molded into useful shapes.

These natural molding materials were the only ones available for centuries—until the invention, in 1869, of the first modern synthetic plastic, celluloid. Today the plastics industry makes dozens of synthetic materials with a wide range of molding characteristics.

General Electric entered the plastics business more than fifty years ago by molding carbon rods for arc lamps from clay and lampblack. Later, G. E.'s plastics operations expanded rapidly, when plastics began to be used extensively in electrical insulation.

As General Electric's plastics operations grew, it became practical to offer plastics services to other companies.



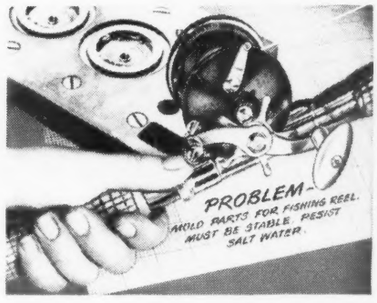
Now General Electric is unique in the industry, being both a manufacturer of plastics molding materials and one of the world's largest plastics molders.

G. E. provides a complete plastics service. It has facilities for producing special types of molding compounds and for designing, engineering, and molding any kind of plastics part or product.

You may breakfast at a dinette table with a surface of G-E Textolite* (a laminated sheet plastics); your toaster may have a base of plastics, molded by G. E.; the breakfast service may be G-E plastics plates and cups in beautiful pastel shades. Your automobile, your refrigerator, your radio, your camera—all are likely to incorporate plastics parts produced by General Electric.

The Scope of G-E Chemical Department's Operations

Molded plastics are just one part of General Electric's Chemical Department's operations. Other products made and sold by the Chemical Department include the amazing new materials of organic-silicon chemistry called silicones, Glyptal* alkyd resins, various insulating materials, and plastics molding compounds. Every month new chemical developments are coming from the G-E research laboratories. And the variety and scope of G-E chemical operations promise to broaden tremendously as this research progresses.



For more information, write Chemical Department, General Electric Company, Pittsfield, Massachusetts.

A message to students of chemistry from

F. W. WARNER

Engineering Manager of the G-E Plastics Division

The rapid growth of the plastics industry in the last ten years offers us some idea of the progress we may expect in plastics within the next decade. For a young man who wants to "grow up" with a rapidly expanding business, the field of plastics seems to offer particularly attractive opportunities.

*REG. U. S. PAT. OFF.

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